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Mass Emissions from Trucks Above 6,000-lb. GVW Gasoline Fueled

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MASS EMISSIONS FROM TRUCKS ABOVE 6,000-LB GVW - GASOLINE FUELED

by
Karl J. Springer
Melvin N. Ingalls

INTERIM REPORT

Prepared for
Environmental Protection Agency
Office of Air Programs
Mobile Source Pollution Control Programs

August 1972

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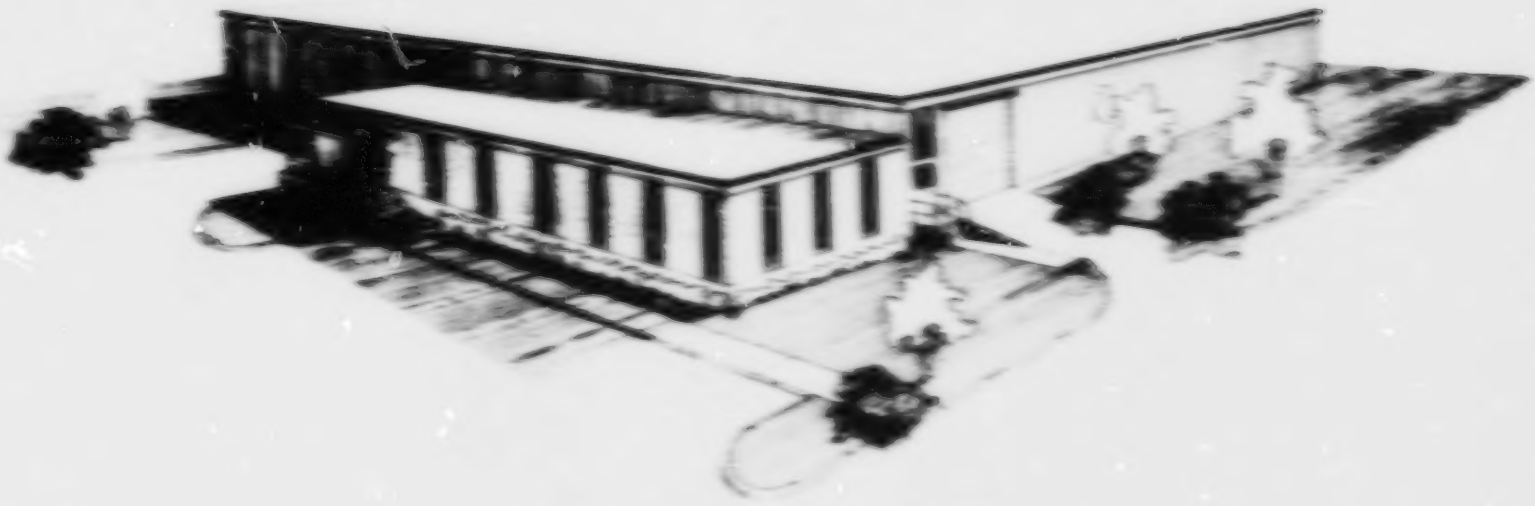

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Approved:

John M. Clark, Jr.
Technical Vice President
Department of Automotive Research

ABSTRACT

This interim report describes the results of mass emissions tests of a number of gasoline powered trucks above 6,000-lb GVW during road driving and chassis dynamometer operation. A constant volume sampler was used to obtain samples during operation on a 7.24 mile course in San Antonio and during the entire 20 minute nine-mode FTP. The agreement between the two, in terms of grams of emission per pound of fuel, was used to determine what road emissions would be from a larger, 145 vehicle, fleet that was subjected to similar CVS nine-mode FTP tests in the laboratory. Consideration of the end use of the data was made with preliminary expressions developed for possible use in determining the contribution of gasoline HDVs to air pollution. In so doing, the objective of this work, to provide data that will assist the EPA to better estimate national impact from this source, has been achieved. Fourteen of the 25 trucks scheduled for road study have been completed. Data for these 14 and all 145 trucks of the surveillance test fleet, used during the laboratory study, are included.

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I. INTRODUCTION

According to the latest statistical information[1]*, all trucks comprise about 16.6 percent (17,871,000) of the total vehicles registered and burn approximately 28.2 percent of the gasoline consumed in the United States. From sales data[1], approximately 42 percent of the trucks and buses sold are above 6,000-lb gross vehicle weight (GVW). This estimate includes diesel vehicles which are a relatively small number. Though there is less knowledge regarding the role of the gasoline-powered engine in heavy-duty vehicle (HDV) operation than say light-duty (cars), the EPA, formerly the National Air Pollution Control Administration (NAPCA), has sponsored a continuing long-range activity at Southwest Research Institute.

A Previous Projects

Southwest Research Institute's Emissions Research Laboratory has been privileged to have conducted a major portion of the research with HDVs beginning in June 1967. Past efforts included acquisition of baseline emissions data from 150 gasoline and LPG fueled spark-ignited engine-powered trucks and buses using three experimental road-like chassis dynamometer procedures. To acquire the emissions, a special truck version of the constant volume sampler (CVS) was used which permitted expression of contaminants on a mass basis. The results of the survey are contained in the SwRI final report[2] which concluded that the three proposed experimental nonconstant speed cycles were not recommended for use in testing emissions from heavy-duty vehicles powered by spark-ignited engines. The findings of these earlier studies were summarized in AIChE and SAE papers[3, 4] which described the preparations and baseline data results, respectively.

The second major work in this continuing program compared road route hydrocarbon (HC), carbon monoxide (CO), and nitric oxide (NO) emissions to chassis dynamometer by the Federal nine-mode constant speed cycle (FTP) for six trucks of various sizes and makes. Using a CVS, the current Federal cycle was subjected to a number of modifications to investigate what improvements might be made to make the Federal procedure agree more with road operation[5].

The third in this series of projects, sponsored by the Environmental Protection Agency, was completed in April, 1972. The first of the three-phase project was a broad emission characterization study of four 1969 trucks under a wide variety of engine speeds, power levels, and both stationary and chassis-operated engines. Emission rates of hydrocarbons, carbon monoxide, and nitric oxide were expressed in mass units of grams per minute, per pound of fuel and per bhp-hr. In addition to the steady-state

*Superscript numbers in parentheses refer to the List of References at the end of this report.

emission maps; a number of transient accelerations and decelerations were studied using a variety of simulated vehicle inertias. The second phase was a four-vehicle study of the effect of four different road routes on emission rates. The road routes were sufficiently different to be distinct, yet were considered representative of actual truck driving. The final phase was a nine-truck evaluation of an experimental 23-mode test procedure using both stationary and chassis-operated engines. The three phases of this project generated a large body of data that is summarized in the report[6] and included in some detail in a number of appendixes.

The precedent for the operation of trucks on a road route and on a closed nine-mode FTP using CVS for mass emission measurement was established in an earlier project completed in July, 1970[5]. This effort utilizes the equipment, instrumentation, route, and approach of this earlier project and in a sense is a continuation.

B. Project Reviews

A project review conference was held on February 14 and 15, 1972, at the Emissions Research Laboratory of SwRI. Personnel in attendance from the EPA were Messrs. Charles Domke and Jim Marzen of the Division of Motor Vehicle Pollution Control and Messrs. Jim Hammerle and David Kircher of the Division of Air Quality and Emission Data. Mr. Karl Springer, Manager of the Emissions Research Laboratory hosted the meeting assisted by members of the Emissions Research Laboratory professional staff, including Messrs. John Storment, Clifford Tyree, and Melvin Ingalls.

The project work and results to that date were reviewed and procedures for the work required in the recent contract revision were discussed. Specific items covered included:

1. A decision to investigate a detailed analysis of surveillance emission data on a percent change in emission level versus mileage basis to ascertain cost and effectiveness of the analysis.

2. A decision to use the 1975 light duty CVS calculation procedures, with the exception of the humidity correction factor for NO_x.

3. Frequency of the propane calibration of the CVS was discussed. It is planned to check the CVS calibration a minimum of once a week.

The equipment and procedures used for the chassis version of the Federal 9-mode heavy duty test procedure were observed during an actual surveillance test. Both the continuous sampling equipment and the CVS

were demonstrated. The road route test procedures were explained and an actual road route run was observed.

Mr. Tom Bejma of the Surveillance and Inspection Branch, Division of Motor Vehicle Pollution Control, Environmental Protection Agency, visited the Emissions Laboratory on June 13 and 14, 1972, to review the project, check test and calibration procedures, and discuss EPA recommendations and requirements for instrumentation calibrations. It is our understanding that the procedures for both truck testing instrumentation and calibration were satisfactory. Several recommendations were made for improvements in instrumentation calibration procedures which were implemented.

C. Scope

This interim report is furnished as requested by the Project Officer and covers the first fourteen vehicles of the road group and all vehicles in the laboratory group. The testing of these vehicles was completed July 31, 1972, as specified in the contract.

II. OBJECTIVE AND APPROACH

The main objective of this project is to determine mass emission rates for use in estimating national impact from gasoline powered HDV's. The project is designed to generate basic data of tailpipe emissions on a mass basis over a road course and during the nine-mode FTP using a CVS. Two groups of vehicles were involved.

A. Road Group

This group consists of 25 1970 or later model vehicles, each studied over a two week period to:

(1) Determine the HC, CO and NO_x emission rates during road operation,

(2) Define truck road operation in terms of percent time in various engine speeds, vehicle speeds, and engine manifold vacuums, etc.,

(3) Determine the HC, CO and NO_x emission rates during chassis dynamometer operation by the nine-mode FTP (concentration) and closed CVS nine-mode FTP (mass) methods, and

(4) Examine the effect of "cold" versus the usual "warm" or "hot" start procedure on emission rates in terms of concentration (standard FTP) and closed nine-mode CVS.

B. Laboratory Group

This group involved the 145 1970 and 1971 vehicles in the surveillance fleet that is currently in operation to determine emissions performance from control equipped engines over a 30 month (approximately 50,000 mile) period.

Simultaneous concentration and mass emission measurements were obtained during a nine-mode test using the FTP and the closed CVS procedure. The objective of these tests (Fourth Round) was to obtain mass emissions on a larger body of vehicles than the road group. Also, the surveillance vehicles represent a greater variety of operation, application, are nearly all non-rental vehicles and represent a wider range of displacements.

C. Utilization of the Results

By relating the Road Group road-to-chassis results from CVS in terms of grams per pound of fuel (g/lb fuel), a factor can then be applied to the

Laboratory Group CVS chassis nine-mode results to estimate their road emissions. These rates, in g/lb fuel, can then be used in determining overall mass emissions from gasoline trucks by multiplying by fuel consumption in gallons per year. An alternative will be to multiply by total miles and dividing by fuel consumption rate in miles per gallon. Assuming production statistics are available by engine displacement, the emission rates per different categories of vehicles can be utilized to estimate national impact. Though the latter is the ultimate purpose of this project, the SwRI efforts were limited to development of basic data and determining the road to FTP dynamometer factor and its application to the Laboratory Group results. National impact estimation will be made by EPA's Office of Air Programs, Applied Technology Division, Air Quality Management Branch, Research Triangle Park, North Carolina.

III. EQUIPMENT, INSTRUMENTS, VEHICLES, ROAD ROUTE, PREPARATIONS AND PROCEDURES

This section contains a brief description of the instruments, equipment and facilities, road course, preparations and procedures used to conduct this project.

A. Exhaust Sampling and Analysis

Two basic types of exhaust sampling techniques were used during this program. The most familiar set of instruments used was the nondispersive infrared (NDIR) sampling train for raw exhaust gases specified in the Federal Register[7] for the nine-mode cycle (FTP). This system is described first. Another technique used was the constant volume sampler (CVS) for diluted exhaust gases and the related analyzers.

(1) Nine Mode Continuous Sampling, Analysis, and Instrumentation

The exhaust gas sampling and analysis for the nine-mode cycle or FTP was with a system similar to that shown in Figure 1. The system meets the requirements and specifications established in the Federal regulations[7] for heavy-duty vehicle exhaust sampling. A component description of the system is detailed in the above referenced Federal regulations. Nominal full-scale concentration levels for the five NDIR analyzers are as follows:

(1) Low-Range HC - 1000 ppm hexane
(2) High-Range HC - 10,000 ppm hexane
(3) CO - 11 percent
(4) CO_2 - 16 percent
(5) NO - 4000 ppm

Although nitric oxide is not included in the current Federal regulations relating to gasoline HDV s, this contaminant was important from a research standpoint.

The output of each analyzer is fed to strip-chart recorders. The concentrations from each trace can be obtained from the continuous traces by hand as specified in the nine-mode FTP. The average concentrations are then transferred to computer cards for further processing to obtain composite values for HC, CO, and NO. This method was used as a back-up to the real time computer system normally used. The computer system shown to the right of the NDIR cart in Figure 1 was designed and assembled by SwRI. This computer utilizes a Data General Super Nova, 8K central processor, and a Computer Products Series RTP 7410 multiplex. The computer program was also prepared by Institute personnel. This computer system was very helpful during this program to determine nine-mode FTP results immediately after completion of the tests. The reliability and repeatability of the on-line

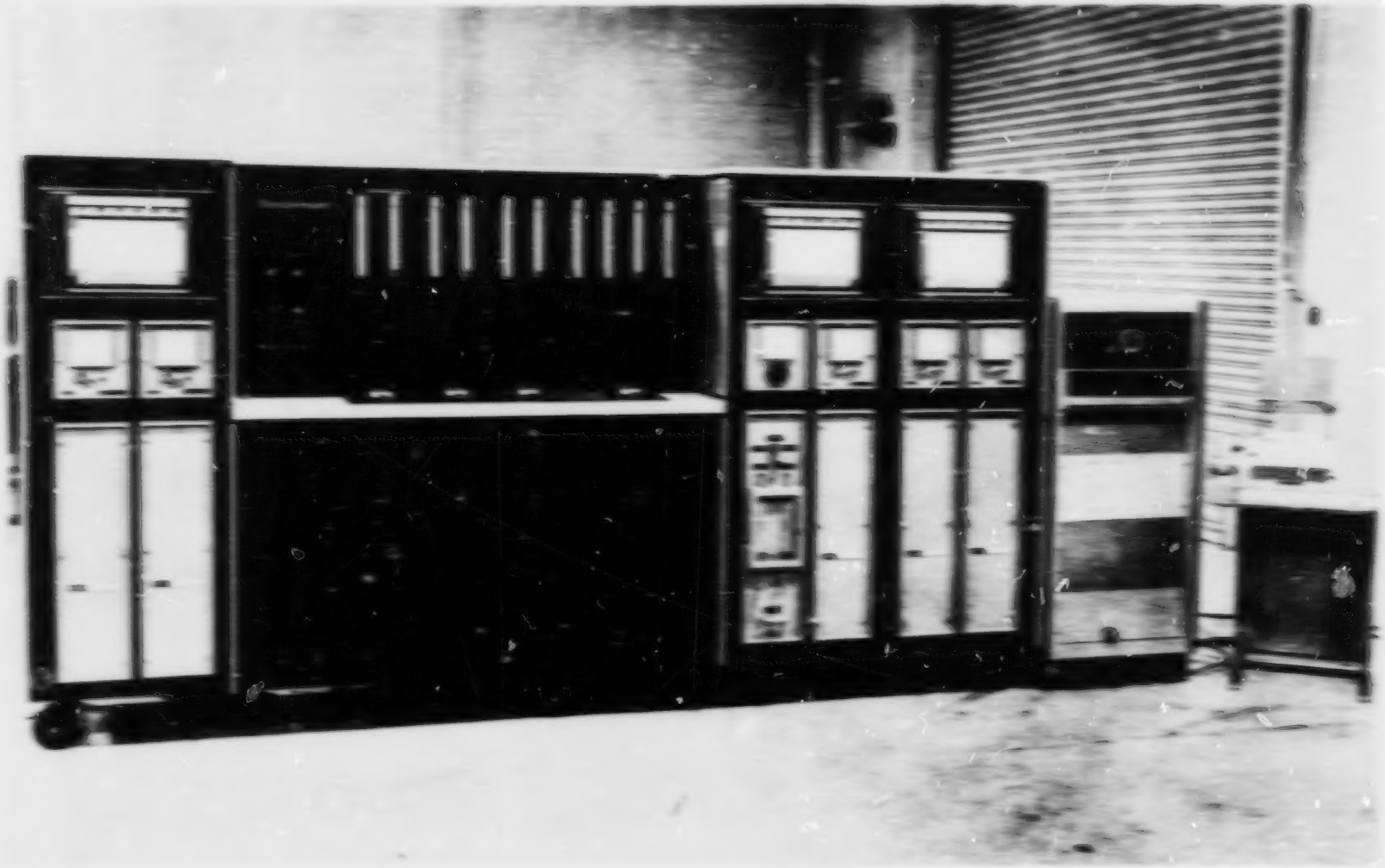


FIGURE 1. CONTINUOUS NOX SAMPLING/ANALYSIS/COMPUTER SYSTEM USED FOR NINE-MODE FTP TESTS

computer has been shown to be equal or better than manual chart reading and computer reduction of data.

The NDIR cart was subjected to a rigorous calibration according to exacting EPA requirements. Both static and dynamic gas simulator tests were run initially on this and a similar hook-up cart by Mr. Matt Maccoche of EPA during the period of September-November, 1971. Recheck of calibrations and instrument response was accomplished periodically during the course of this project by EPA. More frequent calibrations of all NDIR and FIA instruments were made to assure optimum accuracy. One of the EPA checks was to name an unknown to ±1 percent, a difficult requirement since the basic detector is only specified to ±1 percent by the manufacturer. Suffice to say that no tests were made until initial calibrations were satisfactorily completed and an EPA acceptance of time response obtained.

(2) Constant Volume Sampler and Analytical Equipment

This sampling system was an EPA development using the integrated plastic (Tedlar) bag collection technique. The sampler has a nominal flow rate of 600 cubic feet per minute (cfm). The mixture of diluent air plus exhaust gas making up the total flow is cooled in a two-pass stainless steel air-to-air heat exchanger. This sampler is an enlarged version of the original EPA prototype automotive CVS. It was built and calibrated in a previous project and described in an earlier final report[2]. Figure 2 is a schematic of the truck-size CVS. Improvements made in the CVS prior to this project were to incorporate the latest type of diluent air filters as specified in the Federal regulations for the passenger car, light-duty CVS.

Calibration of the CVS was originally accomplished using an orifice plate made according to the specifications of the American Society of Mechanical Engineers Flow Section Handbook as the primary element. With a Meriam Micro-Manometer to measure the change in pressure in 0.001 in. of water increments, the flow was calculated. Temperature and pressure were measured at inlet conditions to the positive displacement blower, and the airflow measured at the upstream orifice plate was plotted against inlet conditions. Recent calibration of the airflow has been made using a Meriam Laminar Flow element with calibration traceable to the National Bureau of Standards.

The CVS was used during dynamometer and road evaluation procedures. The only differences in the operation of the CVS was the power source. For road evaluation, a 25-kw trailer-mounted generator set was used to provide power for the CVS and related test equipment. Figures 3-5 are typical photographs of the CVS mounted in the bed of a truck prepared for road route evaluation. Note the CVS is carried onboard the truck and the 25-kw generator is pulled behind the truck.

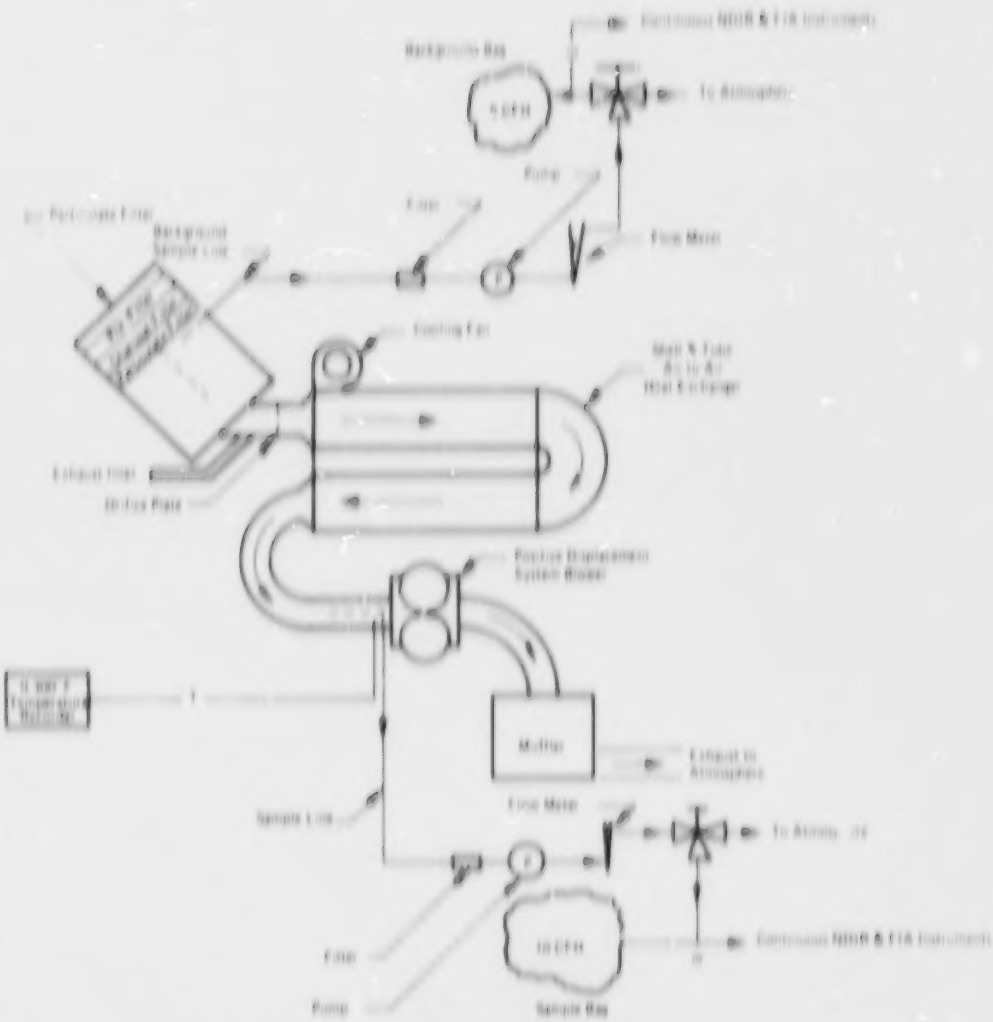


FIGURE 4. SCHEMATIC OF REVISED TRUCK VERSION OF CONSTANT VOLUME SAMPLER

FIGURE 3. STAKE BODY TRUCK PREPARED FOR EXHAUST SAMPLING (Side View)

FIGURE 4. STAKE BODY TRUCK PREPARED FOR EXHAUET SAMPLING (Right Rear View)

FIGURE 5. STAKE BODY TRUCK PREPARED FOR EXHAUST SAMPLING (Left Rear View)

The exhaust contaminants were analyzed with a Beckman 400 flame ionization analyzer (FIA) for HC, NDIR for CO and CO_2, and chemiluminescence (CL) of EPA design for NO and NO + NO_2 (NO_x) as NO_2. The group of instruments were arranged and employed as specified by the applicable Federal Registers [7, 8, 9] for analysis of dilute CVS bags of exhaust and background bags. The arrangement was identical to that specified for 19-5-1976 light duty vehicles as agreed with the Project Officer. The instruments are shown in Figure 6. Calibration of the analytical train was made using as many EPA "named" gases as possible from those used to calibrate the continuous raw exhaust cart. Calibration curves were routinely, monthly, verified using a number of additional calibration gases. This "bag cart" was used for all CVS bags taken during both road and chassis operation of the trucks.

The calculational procedures to convert bag concentrations into grams per test were identical to those detailed in the Federal Register[9]. The formulae, well documented in this Federal Register, were included in a suitable computer program. The results for all such tests were therefore computer reduced and are shown on fairly self-explanatory computer printouts. The common vehicle denominator for expression of results from a given vehicle, both road and chassis, was fuel consumed. Therefore, the final result was computed in terms of grams per test, grams per pound of fuel and grams per mile (applicable only to road operation).

(3) Road Route Instrumentation

Transducers and related test equipment used on the road were similar laboratory devices used in original studies on the San Antonio Road Route[5]. During chassis dynamometer operation, fuel measurements were taken with fuel scales and timers. Manifold vacuum was measured with a Bourdon-tube-type vacuum gauge calibrated against a column of mercury. Engine rpm was measured with Sun electronic tachometers calibrated against a General Radio Strobotac.

During the road route evaluation, engine rpm, manifold vacuum, throttle position, and wheel speed were recorded on strip-chart recorders. The engine rpm was measured as described above. Manifold vacuum levels were converted to DC signals via a Statham strain gauge transducer. Throttle position was obtained via a linear potentiometer. Vehicle speed was measured using a Labeco fifth wheel.

A direct digital data acquisition system, a Metrodata 620A, was used successfully to record on magnetic tape the vehicle and engine operational data. The 620A system is portable, lightweight, 18 lb, and records 20 channels of data. Two of the 20 channels record hours, minutes, and seconds. The data acquisition rate is 2.4 scans per second. One scan is defined as obtaining data from each of the 20 channels and recording it on

FIGURE 6. INSTRUMENTATION SYSTEM FOR ANALYSIS OF HC, CO, CO_2, and NO_x OF DILUTED EXHAUST

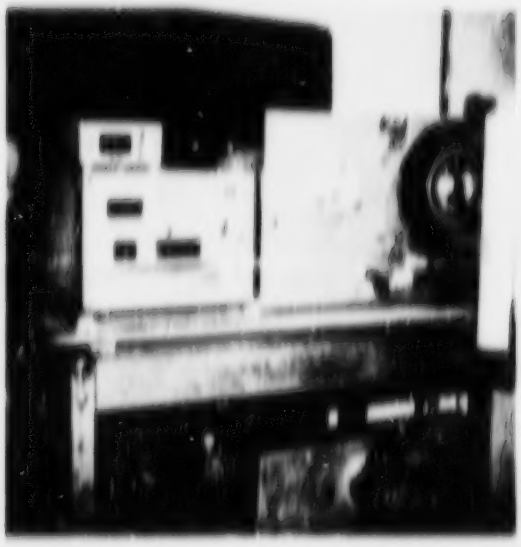


FIGURE 7. PARTIAL VIEW OF INSTRUMENTATION USED TO RECORD ENGINE AND VEHICLE PERFORMANCE

magnetic tape, providing 48 recordings or data points per second.

The strip-chart recorders and transducer equipment was operated by a technician who rode in the van and also operated the CVS. The Metrodata portable magnetic tape data recorder was also located in the van adjacent to the CVS operator. Fuel container and three-way valve remained in the truck cab. Figure 7 shows the Metrodata equipment and tape deck.

The road manifold vacuum, engine rpm, vehicle speed, throttle position (open-closed), and transmission gear position data, recorded on the seven track 0.5 inch magnetic tape, was computer reduced using a suitable, slightly modified "canned" program. In order to define the truck's operation, percent of time at various increments of manifold vacuum, engine rpm, and vehicle speed as well as gear position were the computer outputs. Although several runs were recorded, only one or two such test runs per truck were subjected to complete computer analysis.

B. Chassis Dynamometer

The Swift chassis dynamometer system used in this and previous projects was a modified Clayton CT-200 series dynamometer. Up to 200 hp may be absorbed with this water brake-type of absorber. This system incorporates a 50-hp, three phase, AC electric motor that, when engaged, will maintain a constant rear wheel speed during power and closed throttle (CT) operation. The electric motor is coupled to the front roll of the chassis dynamometer with a positive drive belt. The vehicle engine speed can be changed by changing vehicle rear wheel speeds either by operating in a different transmission drive gear or changing motor drive pulleys.

Figure 8 shows typical views of trucks being evaluated in this facility. The top photograph is a side view of a truck mounted on the dynamometer rolls. In the foreground is the CVS dilution air filter housing containing the prescribed particulate and activated charcoal filters for cleanup of the diluent. Note the stainless steel exhaust pipe located on the floor connecting the engine exhaust to an offset Tee below the filter plenum. The bottom photograph shows a truck prepared for test by the CVS which is located to the left and rear of the truck.

C. Vehicles-Engines Tested

The test vehicles-engines were in two groups. None of the vehicles were selected on the basis of their emission rates, etc., but rather reflect a randomly obtained sample of in-service units.

(1) Road Group

This group will eventually number 25, but at the writing of this interim

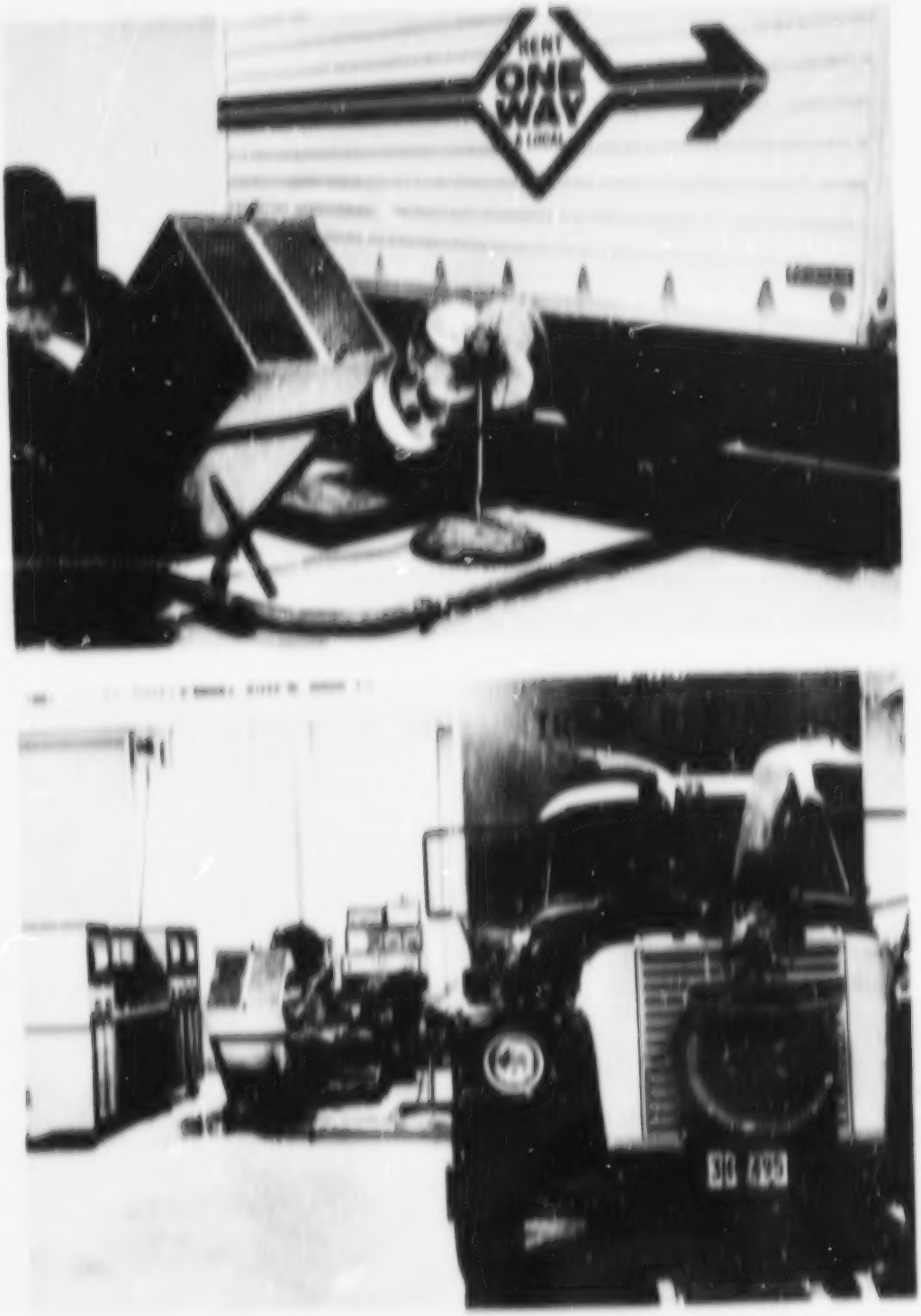


FIGURE 8. CVS AND INSTRUMENTATION USED TO MEASURE EMISSIONS FROM CHASSIS-OPERATED ENGINES

report; the number of vehicles studied so far is 14. They are listed in Table A-1 of Appendix A in the order tested. Many of the vehicles will be replicated once and possibly twice more and, it may be noted, no tractors have been included in the original 14. A group of six tractors will be studied next and use a common trailer especially prepared for road emissions acquisition.

One drawback to this project and previous projects of this type is the difficulty of obtaining trucks from private operators for a two week leakage period. In most all cases, it is not possible to use such vehicles even where rental vehicles are offered because of distinctive truck markings, special bodies, locking arrangements, licensing and insurance. In three instances, trucks 7, 10, and 11 were obtained from non-rental sources. In two instances, trucks 3 and 8, the vehicles were in factory new condition with very low mileage. Of the remaining vehicles, all obtained from rental agencies, the majority are from long term lease operation and were not in transient rental fleet status. One of the fourteen, truck #12, was from the surveillance group and identified as unit 64 of the surveillance fleet.

Another drawback was the non-availability of certain displacements of certain makes. The vehicles available for the required two week period did not cover as wide a variety of displacements as might have been desired. The trucks and engine sizes are, however, the most popular - at least in the Southwest.

It may be noted that only a few vehicles in the recently developed intermediate class of 6001 to 14,000-lb GVW were included in this study. This happened because the space and weight requirements of the CVS and related equipment and generator set are difficult to employ with one ton and three-quarter ton pick-ups and stakes (vehicles in the 6001 to 10,000-lb GVW range). There are a very small, almost negligible number licensed between 10,000 and 15,500-lb GVW. This may be fortuitous in light of recent studies and research directed toward operating vehicles from 6000-14,000-lb GVW on the current light duty driving schedule. The road group is therefore comprised of nearly all trucks above 16,000-lb GVW and considered to be in heavy duty operation as contrasted to light duty operation as is more the case of the 6000-14,000-lb GVW vehicles.

(2) Laboratory Group

This fleet of 145 trucks has been described in detail by reports covering the periodic emission inspection given the surveillance activity of the basic contract. Appendix Table D-1 is a listing of the vehicles and their status, mileage, etc., at the fourth round (12 months of operation) test. Also shown are the fourth round emission results concentrations obtained by a chassis version of the prescribed nine-mode FTP. These emission results are shown to assist in describing the vehicle-engine make-up of the laboratory group.

For purposes of analysis, this fleet has been divided into 23 categories of engine make and displacement. These categories are shown in Table A-3. These categories may be helpful in the analysis of the results disclosed later in this report.

D. Vehicle-Engine Preparation

The two groups of vehicles were prepared slightly differently for testing.

(1) Road Group

These vehicles were subjected to a performance and exhaust system inspection before start of the test to make certain the engine was adjusted to manufacturer's specifications and that the exhaust system was tight. Where found necessary, ignition components such as spark plugs, points and condensor or wires were replaced, though this was seldom required.

Preparations to the engine involved adjustments to factory settings of engine rpm and basic timing according to the EPA tune-up sticker on the engine. Empty, curb, weight of the truck was obtained by weigh scales and the truck loaded with CVS and other equipment plus drums of water to achieve a total vehicle weight of curb weight plus one-half net payload. Net payload weight is herein defined as the license weight minus curb weight.

A suitable trailer hitch for connection of the generator trailer was added. Generally, the vehicle exhaust pipe had to be extended due to the length of the bed. This was done by connecting a long tailpipe extension approximately 1 inch larger in diameter than the conventional short stub pipe after the muffler. The system was sealed. There were no leaks.

The manifold vacuum and engine rpm transducers were installed as well as the "fifth wheel" for mph. The Metrodata tape data system was then calibrated, along with two TI dual pen recorders, against manifold vacuum, engine and vehicle speed. Calibration checks were made of the CVS using the propane injection method. The fuel line to the fuel pump was connected to a preweighed 5-gallon fuel container located in the cab of the truck. The vehicle was then ready for test on either the road course or on chassis dynamometer. Figures 9, 10, and 11 show views of most of the fourteen trucks prepared for road evaluation.

(2) Laboratory Group

No preparations to this group of 145 trucks in the surveillance fleet were made specifically for the CVS test other than adding a suitable exhaust section that would make possible simultaneous sampling by the continuous cart for the nine mode FTP and by the CVS. This item was usually 3 ft. in length and replaced the usual short stub pipe from the muffler or was coupled to it.

Truck #1, 1971 IHC, 345 CID, V8, 16,000-lb GVW

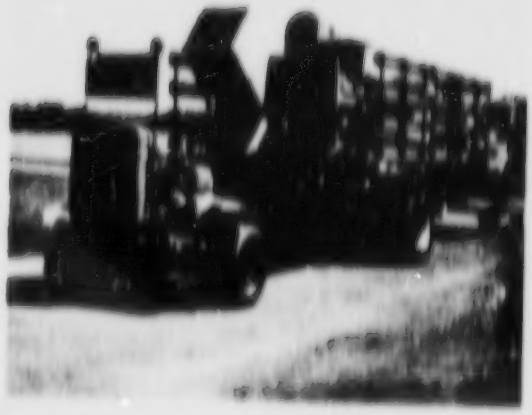
Truck #2, 1970, 350 CID V-8, 18,000 GVW

Truck #3, 1972 IHC, 304 CID, V8 19,000-lb GVW

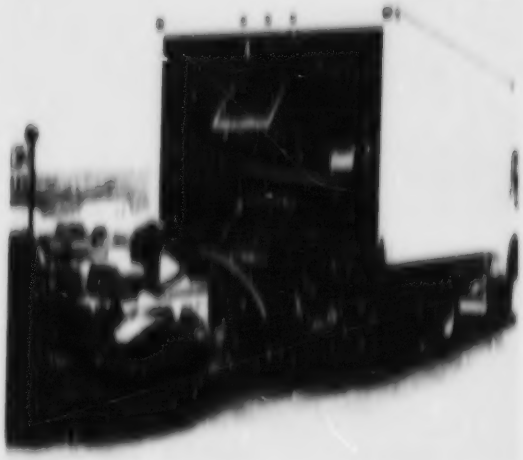
Truck #4B, 1970 Ford, 300 CID, I-6 10,000 GVW

FIGURE 9. EQUIPMENT AND VEHICLES USED ON THE SAN ANTONIO ROAD ROUTE

Truck No. 6, 1972 Ford, 330 CID
V-8, 24,000-lb GVW



Truck No. 7, 1970 GMC, 351 CID
V-6, 19,500-lb GVW



Truck No. 8, 1972 Ford, 391 CID,
V-8, 27,500-lb GVW

Truck No. 10, 1972 Ford, 361 CID,
V-8, 19,500-lb GVW

FIGURE 10. EQUIPMENT AND VEHICLES USED ON THE SAN ANTONIO ROAD ROUTE

Truck No. 11, 1970 Dodge, 318 CID
V-8, 24,000-lb GVW

Truck No. 11, 1970 Dodge, 318 CID,
V-8, 24,000-lb GVW

Truck No. 12, 1972 IHC, 345 CID
V-8, 22,500-lb GVW

Truck No. 12, 1972 IHC, 345 CID,
V-8, 22,500-lb GVW

FIGURE 11. EQUIPMENT AND VEHICLES USED
ON THE SAN ANTONIO ROAD ROUTE

The exhaust systems on all the surveillance trucks were inspected and repaired or tightened where required to provide a leak tight exhaust system. Another item of preparation was to connect a preweighed fuel container to the inlet of the fuel pump for fuel flow rate determination.

The surveillance fleet is tested as-received from the owner. If the basic timing is greater than ± 3° and/or the engine idle rpm is more than ± 100 rpm of the manufacturer's recommended, timing and/or idle are adjusted to factory (sticker) specifications and retest performed. This same practice was followed with as-received and after adjustment tests made with the CVS during the fourth round inspection, after 1 year of operation.

E. Fuel

The fuel used during all emissions tests, both road and laboratory, met the requirements of the Federal Register[5]. A typical fuel analysis of the fuel used and purchased locally is given in Table I.

F. Road Route

The road course used in this project was the same one laid out by Mr. Bob Olsen (EPA Project Officer of Contract PH 86-67-72) and Mr. Karl Springer, SwRI Project Manager, several years ago. It was described in detail in reference 5 as including a variety of truck operation typical of city-suburban delivery.

The intent was merely to develop a road course that involved several different types of driving such as arterial, residential, urban congested (downtown), commercial, and freeway. This course, shown in Figure 12, includes all these types of driving and the course is one that intentionally makes the test truck drive traffic where many other trucks commonly operate. It is 7.24 miles in length and normally requires about 20 minutes to drive completely around. Figure 13 contains three photographs taken from the back of a truck during a test run. The top photo was taken near point 4, the middle photo on the exit of the Interstate Highway near point 7, and the bottom photo was taken between points 7 and 1. The drivers are instructed merely to drive normally, stay with traffic yet not to exceed posted speed limits.

No claim is made about the course as being typical of truck operation in the U.S. or that it is based on driving habit and patterns that have been carefully defined as is the case of the studies of light duty operation sponsored by APRAC. Several years of effort seem necessary to establish a road driving course that could be agreed to as acceptable and typical of U. S. truck operation. This was specifically pointed out in the proposal so that there is no misunderstanding of the basis of the road course used in this project.

TABLE I. INSPECTION OF LEADED PREMIUM MOTOR GASOLINE USED FOR ALL TESTS

Gravity, deg API (D287)	59.3
Distillation Range (D 86)	
Initial Boiling Point, °F	88
5% Point, °F	116
10% Point, °F	127
20% Point, °F	150
30% Point, °F	175
40% Point, °F	200
50% Point, °F	220
60% Point, °F	235
70% Point, °F	254
80% Point, °F	276
90% Point, °F	305
95% Point, °F	327
End Point	340
% Recovery	98.0
% Residue	1.0
% Loss	1.0
Octane No., Research (D1656)	103.4
Total Sulfur, % wt (D1266)	0.004
Reid Vapor Pressure, psi (D323)	9.1
Hydrocarbon Composition (D1319)	
Olefins, %	0.4
Aromatics, %	27.3
Saturates, %	72.3
Lead (Organic) g/gal (D526)	3.271
Phosphorus, Theory	0.0
Oxidation Stability (D525)	600+
Existent Gum, mg (D381)	0.6

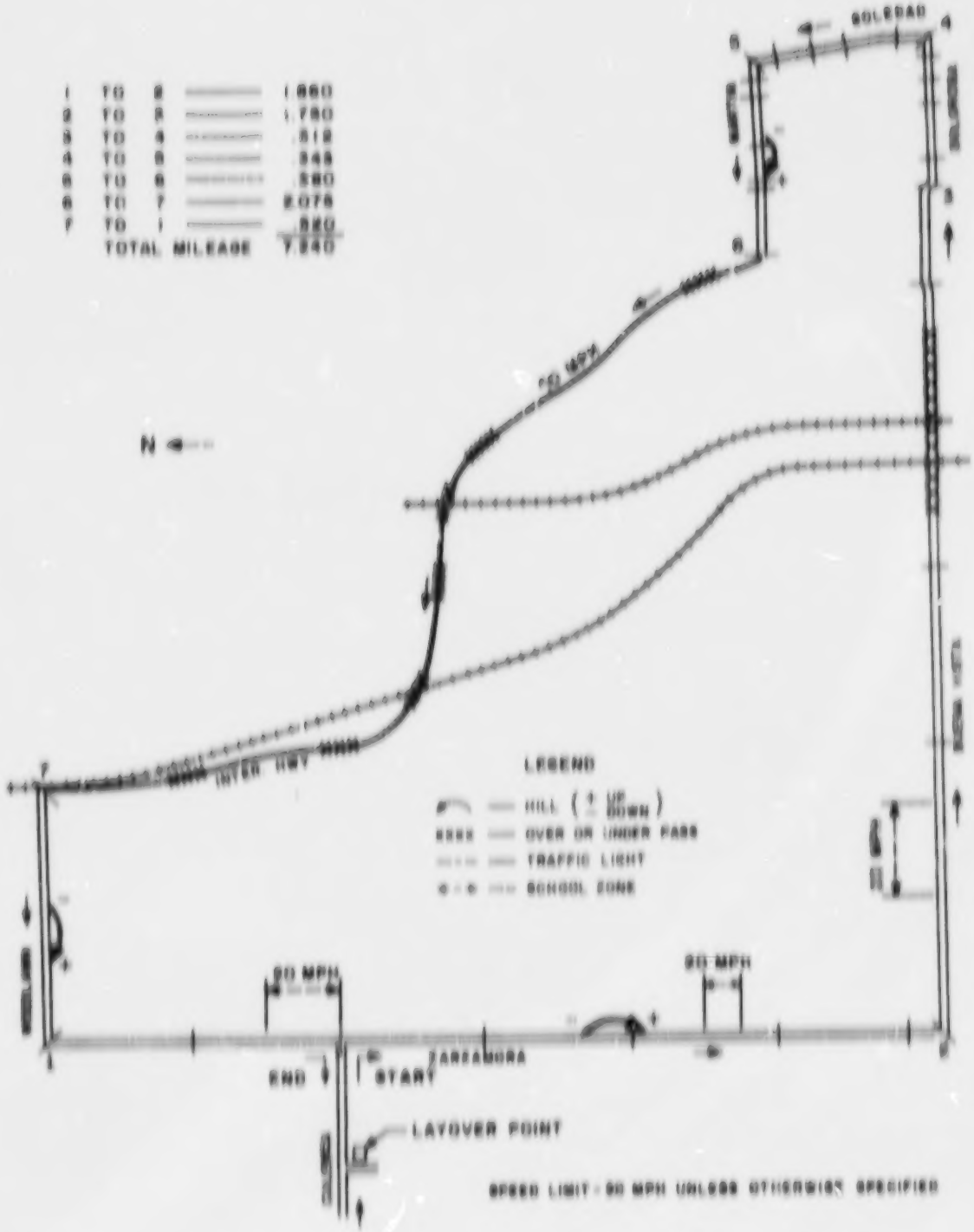


FIGURE 14. SAN ANTONIO HEAVY DUTY GASOLINE TRUCK ROAD ROUTE

Downtown

Expressway

Residential

FIGURE 13. PHOTOS OF THE SAN ANTONIO ROAD ROUTE TAKEN DURING A TEST RUN

G. Nine-Mode FTP Schedule

The laboratory driving schedule for both the road and laboratory groups was a chassis dynamometer version of the nine-mode Federal Test Procedure[10]. This version, contained in the proposed Federal Standards[11] as an as alternate to the stationary method was deleted in the June 4, 1968, final regulations[10].

Part of the surveillance test fleet was to determine the correlation of chassis to stationary operated engines on the nine-mode procedure using ten widely different HDV's. It was found that usually, the chassis test was within ±10 percent of the stationary, although for certain contaminants for certain makes, the difference could be as great as ±25 percent. These findings are summarized in Table A-4 of Appendix A for background information.

The nine-mode FTP, 20 minutes in length, consists of the schedule in Table 2 which is run four times. The weighting factors, listed in the last column, are used to calculate the concentration results.

H. General Test Procedure

The road operated vehicles were subjected to a more extensive series of tests than the laboratory group.

(1) Road Group

Each series consists of obtaining replicate exhaust emissions during the following:

1. Cold start 9-mode Federal Test Procedure (FTP)
2. Warm start 9-mode Federal Test Procedure
3. San Antonio Road Route (SARR)

The first two items involved laboratory operation of the prepared vehicle on several days to obtain replication of both cold and the prescribed warm start nine-mode data. The "cold start" was made as nearly as possible in compliance with the light duty cold start requirements for 1972 and later model year. An overnight soak at 68 to 86° F was observed and the truck CVS and continuous NDIR cart sampling begun when the starter begins cranking the engine. The normal warm start nine-mode FTP begins after a 5-minute pre-run between 1000 and 1200 rpm and no load. Both raw concentration levels and CVS samples were obtained simultaneously. The CVS was operated continuously during the 20-minute version of the test.

The road operation involved normally several days of actual field operation in order to obtain replicate CVS samples for several different drivers. Nine tests, three tests for each of three drivers, was the goal. Sometimes only two tests were made with certain drivers and sometimes four

TABLE 2. CURRENT FEDERAL NINE-MODE CONSTANT SPEED PROCEDURE FOR HEAVY-DUTY GASOLINE TRUCKS

Sequence Number	Manifold Vacuum	Time in Mode, sec	Cumulative Time, sec	Weighting Factors
1	Idle	70	73 (1:10)	0.036
2	16 in. Hg	23	93 (1:33)	0.089
3	10 in. Hg	44	137 (2:17)	0.257
4	16 in. Hg	23	160 (2:40)	0.089
5	19 in. Hg	17	177 (2:57)	0.047
6	16 in. Hg	23	200 (3:20)	0.089
7	3 in. Hg	34	234 (3:54)	0.283
8	16 in. Hg	23	257 (4:17)	0.089
9	Closed Throttle	43	300 (5:00)	0.021

Engine Speed 2300 ± 100 rpm.

An initial 5-min idle, two warmup cycles and two hot cycles constitute a complete dynamometer run.

drivers were used. A small study of driver effect on truck emissions over a stop-and-go road course was recently made as part of the last procedural development project on HDV for EPA (Mr. John Bosek, Project Officer). Pages 72-79 of reference 6, the final report, cover the expected range of variability for the drivers used on the road course. The stop-and-go course in which seven truck drivers were tested involved similar driver functions to that over the SARR and showed statistically that the specific drivers used in this project would produce fairly similar results. They were not given any specific instruction or driver training and only asked to drive normally and not exceed posted speed limits.

IV. RESULTS

The results are discussed in terms of the road and laboratory group of vehicles and then their combined usefulness is considered.

A. Road Group

The results of the 14 vehicles tested to date are summarized as follows:

1. Cold Start - Warm Start FTP Results

Table 3 presents the average emission levels for the FTP cold and warm start tests in terms of both continuous sample volumetric concentrations and CVS grams/lb of fuel for the 14 trucks completed to date. Average data are shown based on usually two "cold" starts and three or more "warm" starts. The actual number of tests is shown in parentheses. One surveillance fleet truck (laboratory group) was also given a single cold-warm start series and is shown on Table 3 as truck number 50.

No gross differences in emissions whether "cold" or "warm" start are evident based on concentration or CVS (g/lb fuel). HC is, more times than not slightly, technically higher during cold starts, while CO and NO_x showed larger differences in HC, the "cold" start being usually higher. NO_x, however, was not usually lower and visual observation of the CO does not indicate any specific trend.

From the testing of this group of trucks so far, it does not seem to matter whether the nine-mode FTP is run from a "cold" start or the usual "warm" start. This conclusion is essentially the same as reported on pages 66 of reference 6. Although the CVS, which is sampling continuously, was more sensitive to the "cold" start in terms of slightly higher HC, the raw exhaust concentration method prescribed by the FTP is little affected. The method of chart reading and subsequent weighting-calculation of the mode concentrations is felt to be the reason.

2. Road and Chassis Emission Results

Table 4 lists the CVS results from both the chassis version of the FTP and the San Antonio Road Route tests. The values listed are CVS in grams per pound of fuel burned, the only common means of expression for a given truck thus operated. A number of chassis runs, usually 3 or more, and a number of road course tests, usually 6 or more by several drivers, are averaged for purposes of this comparison. Appendix B contains NDIR concentration and CVS emissions results for each chassis dynamometer run. One table, on which is listed the road results, is devoted to each truck. Please refer to these more extensive listings of results for an indication of run-to-run repeatability, etc. To facilitate the comparison, the average

TABLE 3. CVS AND CONTINUOUS NDIR RESULTS FROM THE CHASSIS VERSION OF THE FTP FRO COLD AND WARM STARTS

		Continuous NDIR Concentration				Constant Vol. Sampler grams/lb of fuel			
Truck	No. of Tests	HC, ppm as Hexane	CO(%)	Obs. NO(ppm)	Corr. NO(ppm)	HC	CO	NO_x	Fuel Wt., lbs
#1	Cold (2)	252	2.22	2645	2038	10.46	120	16.50	6.82
	Warm (2)	274	3.07	2364	2302	9.61	104	15.68	6.26
#2	Cold (5)	120	2.07	906	765	5.48	115	6.12	7.70
	Warm (6)	139	1.95	987	801	5.57	110	7.34	7.21
#3	Cold (2)	321	2.05	1535	1451	13.43	117	11.33	5.69
	Warm (4)	268	2.03	1586	1388	11.30	120	12.94	5.37
#4B	Cold (3)	154	0.36	2990	2530	7.28	24	28.23	5.00
	Warm (4)	163	0.29	3101	2516	7.04	15	25.47	4.82
#5	Cold (3)	234	2.17	645	672	9.96	125	4.86	7.14
	Warm (4)	213	2.09	767	698	8.49	122	5.96	6.61
#6	Cold (2)	292	0.87	2103	2100	13.13	65	18.50	5.99
	Warm (3)	265	0.68	2269	2273	12.38	52	18.82	5.44
#7	Cold (2)	455	5.79	485	464	16.61	279	2.91	6.06
	Warm (4)	477	6.02	565	518	16.16	286	3.19	5.63
#8	Cold (3)	352	1.28	1852	1800	15.96	95	13.28	7.15
	Warm (5)	293	1.27	2001	1912	14.49	92	15.53	6.42
#9	Cold (3)	297	0.78	2326	2329	13.10	63	17.69	6.10
	Warm (4)	254	0.77	2310	2340	10.76	56	13.81	5.49
#10	Cold (3)	229	0.71	2273	2256	9.15	58	12.76	6.81
	Warm (5)	238	0.64	2270	2241	7.58	46	16.75	6.21
#11	Cold (4)	363	1.47	1730	1745	15.03	95	12.01	6.15
	Warm (5)	323	1.51	1925	1891	12.05	99	14.77	5.75
#12	Cold (3)	298	1.27	1269	1275	12.05	88	8.61	5.90
	Warm (3)	290	1.31	1338	1364	11.87	94	9.61	5.56
#13	Cold (3)	258	0.87	2249	2236	12.39	65	16.31	5.54
	Warm (4)	248	0.89	2388	2353	11.72	64	17.96	4.99
#14	Cold (3)	180	1.14	1349	1368	10.74	90	8.85	6.49
	Warm (5)	173	1.18	1328	1347	9.96	92	9.62	5.94
*Unit 50	Cold (1)	240	2.05	1710	1705	10.07	118	12.60	6.25
	Warm (1)	234	2.24	1755	1725	9.96	128	14.11	5.40

Note: NO concentration is from NDIR.
NO_x in grams/lb of fuel from Chemiluminescence as NO_2.
*These results from surveillance fleet test of Unit 50 of the surveillance fleet.

chassis test results were divided by the average road results to obtain a ratio. Ratios less than one indicate the SARR emissions are greater than the FTP, ratios greater than one indicate the SARR emissions rates were less than the FTP.

Overall, the closed Federal test yielded 85 percent as much HC, 59 percent as much CO and 127 percent as much NO_2 as did the road course. This bears out the fact that the current FTP is a high NO_x producer. Although some variability was noted, especially for some makes, the range of comparison ratios is surprisingly good.

For HC, the 14 trucks ranged from a 0.59 up to 1.21 ratio while CO ranged from 0.17 to 1.00. NO_x varied from 0.69 to 1.60. Except for CO, the average ratios are not substantially away from unity or one-to-one, direct, correlation. Fuel rate or fuel consumption indicated that the energy inputs to each procedure were not grossly different, the FTP consuming on an average of 81 percent as much fuel as the road course.

These findings agree quite well with a similar series of tests with six pre-controlled (1958-1969) trucks. The results, described in Reference 5, are repeated as Table 5 for direct comparison. The major difference was that NO was measured by NDIR instead of CL and will be somewhat lower than the data in Table 4 due to unavoidable conversions. Except for CO, the pre-controlled six truck fleet gave almost identical FTP/SARR ratios. Emission rates of HC and CO were quite similar between the two groups.

3. Vehicle-Engine Performance Data

In addition to measuring emissions during Road Route operation, engine and vehicle performance was also recorded on magnetic tape using an automatic data acquisition system. Engine speed (RPM), manifold vacuum (in. Hg.), vehicle speed (MPH), and throttle position were recorded approximately ten times a second. In addition, transmission position was recorded approximately twice a second. These data were reduced by a computer program to give percentage of time spent at various increments of engine speed, vehicle speed and manifold vacuum.

Table 6 is an overall average of the way in which the 14 trucks operated the road course. Also shown are the max and min values recorded by the group to give some idea of the variability. Little more in the way of analysis of these results can be done at this time. It may be that this data and the detailed truck results, given in Appendix C to this report, will prove of use to the Procedural Development Section of EPA in comparing to the EPA analyzed Ethyl truck and bus survey data[12] (Mr. Preben Ostberg, EPA) or the APRAC Cape 21 project on HDV driving patterns (Mr. John Bozek, EPA or Mark Sherbinsky of IHC). Although six to nine road runs were made for emissions, not all tests were computer reduced for vehicle-engine

TABLE 4. CVS RESULTS FROM CHASSIS VERSION OF THE FTP AND THE SAN ANTONIO ROAD ROUTE

Truck no.	Date	Federal[a] CVS, gr/lb of fuel HC(FIA)	CO	NO_x	Fuel wt.	San Antonio Road Route CVS, gr/lb of fuel HC(FIA)	CO	NO_x	Fuel wt.	mi/gal	Ratio Fed/S.A.R.R. HC(FIA)	CO	NO_x	Fuel wt.
1	1-27-72	9.61	184	15.88	6.26	10.07	145	14.99	6.52	6.95	0.95	0.72	1.06	0.96
2	2-9-72	5.57	110	7.34	7.21	6.93	118	8.57	7.47	6.06	0.80	0.93	0.86	0.97
3	2-22-72	11.30	128	12.94	5.37	13.02	160	8.73	6.89	6.59	0.87	0.67	1.48	0.78
4B	3-6-72	7.04	15	25.47	4.82	5.82	87	19.11	6.09	7.43	1.21	0.17	1.33	0.79
5	3-22-72	8.49	122	5.96	6.61	8.06	166	8.64	7.22	6.27	1.05	0.73	0.69	0.92
6	4-6-72	12.36	52	18.82	5.39	14.91	122	14.05	8.05	5.60	0.83	0.43	1.34	0.67
7	4-17-72	16.16	286	3.19	5.63	17.90	265	3.79	7.36	6.20	0.90	1.08	0.84	0.76
8	4-27-72	14.49	92	15.53	6.42	19.61	162	11.40	8.44	5.36	0.74	0.57	1.36	0.76
9	5-8-72	10.76	96	18.82	5.49	15.91	119	12.41	7.62	5.94	0.68	0.47	1.52	0.72
10	5-26-72	7.71	46	16.26	6.20	12.99	146	12.30	7.46	6.11	0.59	0.32	1.32	0.83
11	6-6-72	12.85	99	14.77	6.75	15.91	141	11.30	7.58	5.97	0.76	0.70	1.31	0.89
12	6-19-72	11.87	94	9.61	5.56	15.17	192	6.29	8.05	5.62	0.78	0.49	1.53	0.69
13	7-6-72	11.72	64	17.96	4.99	12.90	155	11.25	6.29	7.21	0.91	0.42	1.60	0.79
14	7-17-72	9.96	92	9.62	5.94	11.14	139	6.27	8.02	5.66	0.89	0.66	1.53	0.74
	Average	10.65	97	13.72	5.98	12.68	154	10.65	7.36	6.21	0.85	0.59	1.27	0.81

[a]Warm start FTP.

Note: The NO_x as NO_2 measured by chemiluminescence.

TABLE 5. CVS RESULTS FROM CHASSIS VERSION OF THE FTP AND THE SAN ANTONIO ROAD ROUTE

Truck No.	Date	Federal* CVS, gr/lb of fuel HC(FIA)	CO	NO_x	Fuel wt.	San Antonio Road Route CVS, gr/lb of fuel HC(FIA)	CO	NO_x	Fuel wt.	Ratio Fed./S.A.R.R. HC(FIA)	CO	NO_x	Fuel wt.
A	8-19-69	11.75	134	7.99	4.08	13.18	137	6.17	4.12	0.89	0.98	1.29	0.99
B	9-15-69	12.58	135	5.29	6.00	12.35	98	5.95	6.38	1.01	1.38	0.89	0.72
C	10-1-69	10.32	119	9.42	6.34	18.24	171	6.96	6.33	0.57	0.70	1.35	1.00
D	10-22-69	12.97	48	12.93	4.42	11.93	109	8.10	5.86	1.09	0.37	1.60	0.75
E	11-25-69	9.98	129	4.02	6.96	9.79	171	4.97	7.51	1.02	0.75	0.81	0.93
**F	12-15-69	6.79	82	8.73	9.21	11.71	127	7.07	8.64	0.58	0.64	1.23	1.07
	Average	10.72	109	8.06	6.17	12.87	136	6.54	6.81	0.86	0.80	1.28	0.91

*Warm start FTP
**Modified S.A.R.R.

Note: The NO as NO_2 was measured by NDIR.

TABLE 6. ROAD VEHICLE - ENGINE PERFORMANCE SUMMARY
(BASED ON TRUCKS 2, 4B, 6, 8-14)

	Mean Average	Maximum Average	Minimum Average
RPM	[illegible]	[illegible]	[illegible]
Fuel Inj. Hg.	12.48	15.91	11.29
MPH	19.7	23.8	16.3

Manifold Vac. In. of Hg.	Percent of Time at Indicated Level		
	Average	Maximum	Minimum
0-1	6.5	23.7	1.8
1-2	8.1	23.1	2.2
2-3	5.2	9.6	2.4
3-4	3.9	5.7	2.4
4-5	2.9	5.2	1.9
5-6	2.7	4.9	1.6
6-7	2.3	3.6	0.8
7-8	2.2	3.4	1.1
8-9	2.2	2.8	1.1
9-10	2.3	3.3	1.2
10-11	2.1	2.6	1.6
11-12	2.2	2.8	1.3
12-13	2.1	4.0	1.2
13-14	2.5	5.7	1.3
14-15	2.8	9.8	1.4
15-16	2.7	6.5	1.8
16-17	3.9	21.8	1.5
17-18	6.0	26.1	1.2
18-19	5.1	22.1	1.6
19-20	5.6	22.2	2.1
20-21	6.3	22.5	2.1
21-22	6.9	24.6	0.8
22-23	5.6	18.2	0.8
23-24	4.7	12.5	0.8
24-25	2.9	11.4	1.0

Vehicle Speed, mph	Percent of Time at Indicated Level		
	Average	Maximum	Minimum
0-2	15.4	28.9	10.0
2-4	2.2	5.1	1.2
4-6	2.0	2.6	1.2
6-8	2.1	3.0	1.4
8-10	3.1	5.8	2.0
10-12	4.1	5.5	3.1
12-14	4.8	5.9	7.4
14-16	4.8	5.7	3.6
16-18	5.5	6.9	4.2
18-20	5.7	6.9	4.1
20-22	6.5	7.6	4.4
22-24	6.6	7.8	4.9
24-26	6.9	7.7	5.5
26-28	6.3	8.5	4.2
28-30	5.5	7.3	3.1
30-32	4.2	5.3	2.7
32-34	2.6	3.7	1.6
34-36	1.5	2.5	0.8
36-38	1.2	2.2	0.4
38-40	1.3	1.5	0.9
40-42	1.3	3.7	0.2
42-44	1.2	2.3	0.3
44-46	1.4	2.2	0.8
46-48	1.5	3.1	0.4
48-50	1.3	3.1	0.0
50-52	0.9	2.8	0.0
52-54	0.5	1.3	0.0
54-56	0.2	0.8	0.0
56-58	0.0	0.2	0.0

Engine rpm	Percent of Time at Indicated Level		
	Average	Maximum	Minimum
0-200	0.0	0.0	0.0
200-400	0.0	0.2	0.0
400-600	2.5	26.0	0.2
600-800	11.0	28.3	0.1
800-1000	5.4	26.4	2.3
1000-1200	5.9	9.9	3.3
1200-1400	6.7	22.8	5.1
1400-1600	12.3	31.8	7.4
1600-1800	13.3	26.1	9.3
1800-2000	10.4	25.3	8.3
2000-2200	7.3	15.6	3.5
2200-2400	5.6	9.4	3.4
2400-2600	4.9	7.3	2.9
2600-2800	4.3	7.0	1.8
2800-3000	2.2	4.0	0.7
3000-3200	1.7	5.2	0.3
3200-3400	2.4	4.3	0.3
3400-3600	0.5	2.9	0.0
3600-3800	0.0	0.5	0.0
3800-4000	0.0	0.2	0.0
4000-4200	0.0	0.1	0.0
4200-4400	0.0	0.1	0.0
4400-4600	0.0	0.1	0.0

operation. One, and many times two, runs were selected at random and processed. These computer print-outs are included in Appendix C.

B. Laboratory Group

CVS and concentration tests were made per the nine-mode FTP, chassis version, with the laboratory group of 145 surveillance vehicles at the fourth round inspection (after 12 months of operation). A listing of the results is contained in Appendix D. Table D-1 shows the results by the FTP continuous NDIR cart in terms of HC as ppm H. Hexane, CO and CO_2 as percent and NO as ppm. These fourth-round results are summarized on text Table 7 along with the first three rounds for comparison. The average emissions from the fourth round may be seen to be quite similar to the first three inspections.

Tables D-2 through D-5 are fourth round HC, CO and NO (observed and corrected) by engine make - displacement category. The listings are in ascending order of the mean values. Table D-6, in Appendix D, lists the as-received test CVS results in terms of grams per pound of fuel burned and grams per test. This data, like that listed in Table D-1, was for the vehicle in as-received condition. To summarize this extensive series of tests, text Table 8 lists the average, maximum, minimum and standard deviation emissions in grams per test and per pound of fuel for all 145 trucks. Appendix Tables D-7 through D-9, like Tables D-2 through D-5, list the HC, CO and NO_x for the 23 classifications of engine make and displacement in ascending order. These breakdowns of the results are furnished for possible use by EPA in estimating national impact values.

Comparing the maximum divided by the minimum grams per test values (CVS) to the same type ratio for the concentration data, per test, it may be seen that the CVS tracks the NDIR system at least in response to the driving cycle. If the NDIR system showed a large variation for CO, for instance of say about 30 times (4.90/0.15), the CVS also showed about the same (1513/44). Some strength and confidence in the test and test results is gained by these indications.

Appendix Tables D-10 and D-11 list the results of NDIR concentration and CVS emissions on those vehicles that required tune adjustment and were retested as part of the fourth round inspection. For completeness, CVS data was obtained along with usual concentrations where timing was greater than ± 3° and/or idle speed was greater than ± 100 rpm of factory, sticker, specification. Appendix Tables D-12 and D-13 indicate the percent difference the adjustment makes on emission rates. The CVS differences, on Table D-13, are based on grams per test. In the event the data on the surveillance fleet should all be on an "in-specification" basis, the data in Tables D-10 and D-11 can be substituted into Tables D-1 and D-6.

TABLE 7. AVERAGE FLEET EMISSION LEVELS

	HC ppm n. Hex	CO %	NO_x ppm Observed	NO_x ppm Corrected
1. First Round, Zero Months Operation (152 trucks)				
Average	238	1.63	1768	1698
Maximum Value	615	5.51	3985	3957
Minimum Value	63	0.26	423	378
Standard Deviation	66	0.81	655	624
2. Second Round, 4 Months Operation (148 trucks)				
Average	264	1.73	1882	1876
Maximum Value	420	6.56	3488	3314
Minimum Value	139	0.31	483	429
Standard Deviation	52	0.88	585	565
3. Third Round, 8 Months Operation (148 trucks)				
Average	261	1.89	1940	1911
Maximum Value	1838	11.92	3911	3879
Minimum Value	95	0.19	272	266
Standard Deviation	149	1.19	588	598
4. Fourth Round, 12 Months Operation (145 trucks)				
Average	273	1.79	1866	1703
Maximum Value	2093	4.90	4008	3696
Minimum Value	120	0.15	439	378
Standard Deviation	219	0.85	677	594

TABLE 8. CVS RESULTS FROM
TESTS OF SURVEILLANCE FLEET (145 TRUCKS)

	grams/test			grams/lb of fuel		
	HC	CO	NO_x	HC	CO	NO_x
Average	64	569	73	11.03	97	13.47
Maximum	454	1513	155	54.43	234	37.13
Minimum	27	44	23	5.08	9	3.34
Standard Deviation	45	292	29	5.85	40	6.30

C. Use of Results

There are many uses that can be made of the results in this report for the first 14 trucks. As an example, suppose it is desired to determine from as large a data base as possible, the road emissions of HC, CO and NO_x on a grams per mile and/or a grams per lb (or gallon) of fuel.

From the results obtained so far, it appears that a usable correlation of road to chassis emissions is being substantiated. Further tests of the remaining eleven trucks should improve on this relationship but are not expected to materially change it. In the interim, the following factors could be used to estimate impact. These are simplified in that they assume the 14 truck results reflect the population, both in number and composition. They also assume that the S,A,R,R, gives emissions that are not unlike trucks driven in urban areas nationwide.

HC: Divide chassis results by 0.85 to get road emission rate

CO: Divide chassis results by 0.59 to get road emission rate

NO_x as NO_2: Divide chassis results by 1.27 to get road emission rate

These factors may be used on the 145 truck laboratory group (surveillance fleet) CVS results (chassis version of FTP) to get road emission rates based on a large number of vehicles. Using the data (mean values) from Table 8, these values for HC are:

$$\text{Road HC: } \frac{\text{grams}}{\text{pound of fuel}} = \frac{11.03 \text{ grams HC}}{\text{pound fuel}} \left(\frac{1}{0.85}\right) = \frac{12.98 \text{ grams HC}}{\text{pound fuel}}$$

for the fuel used, API Gravity 59.3° at 60/60 and density is 6.24 pounds per gallon

$$\frac{\text{grams HC}}{\text{gal of fuel}} = \frac{12.98 \text{ grams HC}}{\text{lb of fuel}} \left(\frac{6.24 \text{ pounds}}{\text{gallon}}\right) = \frac{80.995 \text{ grams HC}}{\text{gallon}}$$

There are many ways to use this value to obtain a simplified, unweighted impact for say an average truck. Assuming the average truck travels 12,329 miles per year (from the first year of surveillance project) with a fuel consumption of say 6.21 miles per gallon (from the 14 truck road operation) then the average vehicle's HC emissions may be estimated as

$$\text{Road HC for an avg. truck} = \frac{80.995 \text{ grams HC}}{\text{gallon}} \left(\frac{\text{gallon}}{6.21 \text{ mi.}}\right) \left(\frac{12,329 \text{ mi}}{\text{year}}\right) = \frac{160,803 \text{ grams HC}}{\text{year}}$$

The same simplified approach can be used to determine CO and NO_x as NO_2.

The equations may be written as:

$$\text{Road CO for an average truck} = \frac{97 \text{ grams CO}}{\text{lb fuel}} \left(\frac{1}{0.59}\right)\left(\frac{6.24 \text{ lbs fuel}}{\text{gallon}}\right)\left(\frac{\text{gallon}}{6.21 \text{ mi}}\right)\left(\frac{12,329 \text{ miles}}{\text{year}}\right) = \frac{2,036,763 \text{ grams CO}}{\text{year}}$$

$$\text{Road } NO_x \text{ as } NO_2 \text{ for an average truck} = \frac{13.47 \text{ grams } NO_2}{\text{lb fuel}} \left(\frac{1}{1.27}\right)\left(\frac{6.24 \text{ lbs fuel}}{\text{gallon}}\right)\left(\frac{\text{gallon}}{6.21 \text{ miles}}\right)$$

$$\left(\frac{12,329 \text{ miles}}{\text{year}}\right) = \frac{131,397 \text{ grams } NO_2}{\text{year}}$$

Then, the above could be multiplied by the total number of trucks in operation to obtain yearly contribution of trucks above 6,000-lb GVW.

It must be emphasized that these calculational approaches are extremely simplified and based on a number of assumptions. A better, more dependable, method would be to use the data from the 145 vehicles by engine make and displacement and determining, from the population of these different makes and displacements their yearly mileage and fuel consumption rates. This approach, however, is more difficult because of the general lack of data on population, usage, mileage, and fuel consumed.

It may be possible to weight the 145 truck results, as well as the road group results to national sales or population by make and engine displacement and possibly vehicle size. Fairly good statistics are available by make or GVW (but not make and GVW) as far as national population is concerned but a breakdown by make, displacement, as well as size has not been uncovered by our staff. Since this is beyond the scope of this project and could well be a sizeable job of its own, nothing further in this regard has been done.

For what good it may be, the operating experience gained with the 23 classifications is presented in Appendix D as Table D-15. The mileage values are for the 12 month period thus far covered by the surveillance fleet. Effort is being made to obtain miles per gallon values from fleet operational data or best estimates of the fleet owner or manager. In the meantime, the fuel consumption of the 14 road operated vehicles determined by direct measurement over the 7.24 mile long S, A, R, R, was shown in Table 4. Recall that a fuel factor or ratio was computed and shown on this table. It is possible to use this factor with the fuel consumed in pounds for each vehicle make and CID class with the entire 145 truck fleet. This would result in a lbs of fuel per road route of 7.24 miles. Thus, a class or overall fuel consumption (mpg) could be determined at least for the 145 trucks had they been operated on the S, A, R, R. To illustrate, the following is offered:

S. A. R. R. Road Fuel Consumption $\frac{\text{miles}}{\text{gallon}} = \left(\frac{7.24 \text{ miles}}{\text{S. A. R. R.}}\right)\left(\frac{\text{FTP Test}}{5.65 \text{ lbs}}\right)\left(\frac{0.81 \text{ S. A. R. R.}}{\text{FTP}}\right)$

$$\left(\frac{6.24 \text{ lbs}}{\text{gal}}\right) = 6.48 \text{ mpg}$$

where $\frac{5.65 \text{ lbs}}{\text{test}}$ is the average fuel necessary for the 145 trucks to operate on the Nine-Mode 20-min chassis test

$\frac{6.24 \text{ lbs}}{\text{gal}}$ is density of fuel

0.81 is the factor $\frac{\text{S. A. R. R. fuel lbs.}}{\text{FTP fuel lbs}}$ determined by 14 truck fleet.

This miles per gallon could be used in the previous equations as well as the average mileage per year to define the road emissions in grams per year for the 145 truck fleet. The question then remains, how representative of the national population is this fleet in composition and number of vehicles per classification. At this point, the fleet results could be weighted by population statistics, to the extent available, and then an average vehicle fuel rate (mpg) and yearly mileage accumulation to gain a more accurate estimate of tailpipe emissions contribution.

Little has been said about the usefulness of the nine-mode FTP fourth round results obtained simultaneously with the CVS by the continuous NDIR system per the usual procedure. First, the agreement between the road group and the laboratory, surveillance, fleet can be examined on an emissions and fuel consumed basis. The mean, maximum and minimum values are shown in Table 9.

TABLE 9. NINE-MODE FTP (CHASSIS VERSION) CONCENTRATION RESULTS COMPARISON OF ROAD AND LABORATORY GROUPS

Test Group		HC ppm n. Hex	CO %	NO obs ppm	NO corr. ppm	Fuel lbs
Road Group	Max	472	6.02	2388	2516	7.21
(14 Vehicles)	Min	139	0.29	565	518	4.82
	Avg	251	1.62	1796	1710	5.83
Laboratory Group	Max	2093	4.90	4008	3696	9.29
(145 Vehicles)	Min	120	0.15	439	378	3.25
4th Round	Avg	273	1.79	1866	1703	5.65
As-Received						

From the preceding table, the two groups seemed to demonstrate fairly close and comparable average values. The maximum and minimum values did not show the extremes, in the case of the smaller road group as were shown in the larger group of 145 trucks.

The other major use of the concentration results is to compute, even if crudely, a factor that could be used to relate the nine-mode FTP concentrations to grams per mile over the road course. It may be helpful to have a rough idea of what current and projected standards would be equivalent to in mass per mile. This may be especially helpful if current national estimates have been related to Federal concentration limits.

One way to do this would be to determine what one ppm n. Hexane is equivalent to in terms of grams of HC per mile.

$$\text{HC: } \frac{\text{one FTP}}{251 \text{ ppm n. Hex}} \left(\frac{12.88 \text{ grams HC}}{\text{lb fuel}}\right)\left(\frac{7.36 \text{ lb fuel}}{1 \text{ Road Test}}\right)\left(\frac{1 \text{ Road Test}}{7.24 \text{ miles}}\right)$$

or

$$1 \text{ ppm n. Hex} \left| \text{FTP} = \left(\frac{12.88 \text{ grams HC}}{\text{lb fuel}}\right)\left(\frac{7.36 \text{ lb fuel}}{7.24 \text{ miles}(251)}\right) = \frac{0.052165 \text{ gr HC}}{\text{mile}}\right.$$

For the 145 truck laboratory fleet, the average HC was 273 ppm n. Hex by the nine-mode test. Assuming <u>both</u> fleets, the laboratory and road, represent not only <u>population</u> but usage nationally, a big assumption, the contribution of trucks on a per mile basis could be determined as follows:

$$\text{Fleet HC (145 truck surv.)} \left| \text{average truck} = (273 \text{ ppm n. Hex})\left(\frac{0.052165 \text{ grams HC}}{1 \text{ ppm n. Hex} \cdot \text{mile}}\right) = \frac{14.24 \text{ grams HC}}{\text{mile}}\right.$$

Also, the current and proposed Federal limits can be related to road emissions as follows:

$$\text{Current Limit (275 ppm n. Hex)}^1 \quad \text{HC} = 275 \text{ ppm n. Hex} \left(\frac{0.052165 \text{ grams HC}}{1 \text{ ppm Hex} \cdot \text{mile}}\right) = \frac{14.35 \text{ grams HC}}{\text{mile}}$$

$$\text{Proposed 1973 Limit (160 ppm n. Hex)} \quad \text{HC} = 160 \text{ ppm Hex} \left(\frac{0.052165 \text{ grams HC}}{1 \text{ ppm Hex} \cdot \text{mile}}\right) = \frac{8.35 \text{ grams HC}}{\text{mile}}$$

In a similar way, CO and NOx may be treated. The factor for CO would be:

$$\text{CO: } \frac{\text{one FTP}}{1.62\% \text{ CO}} \left(\frac{154 \text{ grams CO}}{\text{lb fuel}}\right)\left(\frac{7.36 \text{ lbs fuel}}{1 \text{ Road Test}}\right)\left(\frac{1 \text{ Road Test}}{7.24 \text{ miles}}\right)$$

$$\text{or} \quad 1\% \text{ CO} \left| \text{FTP} = \frac{154 \text{ grams CO}}{\text{lb fuel}} \left(\frac{7.36 \text{ lb fuel}}{7.24 \text{ miles}(1.62)}\right) = \frac{96.64 \text{ grams CO}}{\text{mile}}\right.$$

$$\text{Fleet CO (145 truck surv.)} = \text{average truck} \left| \; = (1.79\%\ \text{CO}) \left(\frac{96.64\ \text{grams HC}}{1\%\ \text{CO} \cdot \text{mile}}\right) = \frac{172.99\ \text{grams CO}}{\text{mile}}\right.$$

$$\text{Current Limit (1.5\% CO)}: \quad \text{CO} = 1.5\%\ \text{CO} \left(\frac{96.64\ \text{grams CO}}{1\%\ \text{CO} \cdot \text{mile}}\right) = \frac{144.96\ \text{grams CO}}{\text{mile}}$$

$$\text{Proposed 1973 Limit: (0.8\% CO)} \quad \text{CO} = 0.8\%\ \text{CO} \left(\frac{96.64\ \text{grams CO}}{1\%\ \text{CO} \cdot \text{mile}}\right) = \frac{77.31\ \text{grams CO}}{\text{mile}}$$

For oxides of nitrogen (NO_x) as grams of NO_2, the corrected FTP data is used

$$NO_x: \left(\frac{\text{one FTP}}{1710\ \text{ppm HC}}\right)\left(\frac{10.65\ \text{grams NO}_2}{\text{lb fuel}}\right)\left(\frac{7.36\ \text{lb fuel}}{\text{road test}}\right)\left(\frac{\text{Road Test}}{7.24\ \text{miles}}\right)$$

$$\text{or} \quad 1\ \text{ppm NO} \left| \; = \left(\frac{10.65\ \text{grams NO}_2}{\text{lb fuel}}\right)\left(\frac{7.36\ \text{lb fuel}}{7.24\ \text{miles}(1710)}\right) = \frac{0.006331\ \text{grams NO}_2}{\text{mile}}\right.$$

$$\text{Fleet NO}_x\ \text{(145 truck surv.)} \left| \; = (1703\ \text{ppm NO})_{\text{average truck}} \left(\frac{0.006331\ \text{grams NO}_2}{1\ \text{ppm NO} \cdot \text{mile}}\right) = \frac{10.78\ \text{grams NO}_2}{\text{mile}}\right.$$

$$\text{Proposed 1973 Limit (2000 ppm NO)}: \quad \text{NO}_x = (2000\ \text{ppm NO}) \left(\frac{0.006331\ \text{grams NO}_2}{1\ \text{ppm NO} \cdot \text{mile}}\right) = \frac{12.66\ \text{gr NO}_2}{\text{mile}}$$

In using the above in national impact, it must be recalled that it is assumed that the 14 vehicle and 145 vehicle fleets represent national population and usage. The strength of this assumption is unknown and accordingly, the factors and their usage must be with care.

In conclusion of this section, there are a number of ways to extend the data obtained by the road group to the national population for estimation of emissions impact. The calculation methods discussed in this section are fairly crude and may be vastly improved, depending on the time, effort and availability of satisfactory truck statistics. The latter may be the biggest stumbling block to fairly precise nationwide estimates.

V. SUMMARY

This interim report describes the results and how they were obtained from a group of 14 trucks operated over the San Antonio Road Route and the 145 truck surveillance fleet operated in the laboratory. The results are basically in grams per pound of fuel consumed using a CVS during road tests and closed cycle dynamometer operation using a chassis version of the current FTP for gasoline trucks above 6000-lb GVW. Methods are discussed for the use of these results to estimate truck emissions on a yearly or national basis. All that remains is the test of nine more trucks to complete the road group of 25 vehicles. This report will then be revised to include the additional vehicles and issued as a final report.

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7. Federal Register, Vol. 36, No. 219, Department of Health, Education and Welfare, November 10, 1970.

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9. Federal Register, Vol. 36, No. 128, Department of Health, Education and Welfare, July 2, 1971.

10. Federal Register, Vol. 33, No. 100, Part II, Department of Health, Education and Welfare, June 4, 1968.

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APPENDIX A

DESCRIPTION OF ROAD VEHICLES STUDIED

LISTING OF LABORATORY GROUP BY ENGINE MAKE-DISPLACEMENT CATEGORIES

CORRELATION OF CHASSIS TO STATIONARY OPERATED ENGINE NINE-MODE CONCENTRATION RESULTS

TABLE A-1. DESCRIPTION OF SAN ANTONIO ROAD ROUTE TEST VEHICLES TESTED AFTER JANUARY, 1972

No.	Year	Make	GVW	CID	Cyl.	Body	Date	Mileage	Source	Transmission
1	1971	IHC	16,000	345	V-8	Van	1-27-72	9,849	ABC	4-spd
2	1970	Chev.	16,000	350	V-8	Van	2-09-72	7,195	EZ Haul	4-spd
3	1972	IHC	24,000	304	V-8	Van	2-22-72	474	ABC	5-spd
4B	1970	Ford	10,000	300	I-6	Van	3-06-72	19,596	Hertz	3-auto
5	1970	Chev.	16,000	350	V-8	Van	3-22-72	16,573	EZ Haul	4-spd
6	1972	Ford	24,000	330	V-8	Van	4-06-72	10,032	Ryder	5-spd
7	1970	GMC	16,500	351	V-6	Stake	4-13-72	31,963	Dot Metal	4-spd
8	1972	Ford	27,500	391	V-8	Van	4-26-72	48	Grande Ford	5-spd
9	1972	Ford	24,000	330	V-8	Van	5-04-72	8,847	Ryder	5-spd
10	1972	Ford	19,200	361	V-8	Van	5-25-72	6,180	Keebler	4-spd
11	1970	Dodge	24,000	318	V-8	Van	6-06-72	41,662	Red Arrow	4-spd
12	1972	IHC	22,500	345	V-8	Van	6-19-72	7,376	ABC	5-spd
13	1972	IHC	17,000	304	V-8	Van	7-7-72	20,417	Hertz	4-spd
14	1972	IHC	24,500	345	V-8	Van	7-17-72	2,067	ABC	5-spd

TABLE A-2. GASOLINE SURVEILLANCE FLEET MAKE AND CID CATEGORIES
(as of Fourth Round Inspection)

Category	No. of Vehicles	Make	CID	Cyl	Source	GVW	Unit Numbers
1	4	Chevrolet	250	6	C.P.S.B.	7,500	31, 32, 35, 37
2	2	Chevrolet	292	6	C.P.S.B.	9,000	30
				6	City P&R	14,000	94
3	10	Chevrolet	307	V8	C.W.B.	7,500	60, 61, 85
				V8	Lone Star	6,600	80
				V8	City P&R	7,500	104, 107, 110, 111
				V8	City P&R	10,000	106, 109, 112
4	7	Chevrolet	350	V8	JFC	24,000	145, 146, 147, 148, 149, 150, 152
5	2	Chevrolet	366	V8	C.W.B.	32,000	62, 63
6	2	Chevrolet	427	V8	Southern	32,500	103, 151
7	8	Dodge	225	6	State Hosp.	7,500	75, 76, 77, 88
				6	State Hosp.	10,000	86, 87, 89, 90
8	15	Dodge	318	V8	P.O.D.	7,000	125, 126
				V8	Pearl	7,500	53, 118, 119, 120
				V8	C.W.B.	7,500	66, 67
				V8	P.O.D.	10,000	1, 2, 3, 4, 5,
				V8	Red Arrow	24,000	64, 65
9	3	Ford	240	6	Hertz	7,500	21
				6	B.C.R.D.	7,500	96, 97
10	14	Ford	300	6	Pearl	7,500	54
				6	Hertz	10,000	20
				6	C.P.S.B.	10,000	27, 28, 29
				6	C.P.S.B.	16,000	39, 40, 41, 42, 43, 44, 45
				6	Herder	21,000	81, 82
				6	Brown Exp.	24,000	33, 34, 35
11	1	Ford	302	V8	State Hosp.	6,800	78
12	4	Ford	330	V8	B.C.R.D.	21,000	98, 99, 100, 101

Table A-2 (Con't). Gasoline Surveillance Fleet Make and CID Categories (as of Fourth Round Inspection)

Category	No. of Vehicles	Make	CID	Cyl	Source	GVW	Unit Numbers
13	5	Ford	360	V8	B.M.W.	6,100	102
				V8	B.M.W.	7,500	93
				V8	City P&R	8,300	92, 95, 106
14	3	Ford	361	V8	Herder	22,000	83, 84
				V8	C.W.B.	25,500	68
15	4	Ford	391	V8	Lone Star	27,500	127, 128, 129, 141
16	5	GMC	292	6	Pearl	7,500	52
				6	Pace	10,000	121, 122, 123, 124
17	2	GMC	350	V8	Elmore	10,000	117
				V8	Elmore	14,000	116
18	1	GMC	401	V6	State Hosp.	27,000	79
19	13	IHC	304	V8	Pearl	7,500	51
				V8	C.W.B.	10,000	49, 50
				V8	C.P.S.B.	14,000	36, 38
				V8	C.P.S.B.	19,700	46
				V8	C.W.B.	19,700	47, 48, 55, 56, 57, 58, 59
20	8	IHC	345	V8	City P&R	19,000	91
				V8	N.S.S.D.	22,000	18, 19
				V8	C.P.S.B.	25,000	71, 72
				V8	N.S.S.D.	25,500	15, 16, 17
21	21	IHC	392	V8	C.P.S.B.	24,000	113
				V8	C.P.S.B.	25,500	22, 23, 24, 25, 69, 70, 73, 74, 114, 115
				V8	City P&R	25,500	105
				V8	S.A.P.W.	34,000	130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140
22	7	IHC	478	V8	Ryder	32,000	11, 12, 13, 14
				V8	ABC	32,000	142, 143, 144
23	5	White	400	6	ABC	30,000	6, 7, 8, 9, 10

145 Total (7 trucks lost from test since first inspection.

TABLE A-3. SUMMARY OF CORRELATION TRUCK RESULTS
4-MODE HEAVY DUTY GASOLINE FEDERAL CYCLE
STATIONARY TO CHASSIS DYNAMOMETER COMPARISON

Truck	HC - PPM - HEX.			CO, %			NO - PPM					
							Observed			Corrected		
	Average Station.	Average Chassis	% Diff.*	Average Station.	Average Chassis	% Diff.*	Average Station.	Average Chassis	% Diff.*	Average Station.	Average Chassis	% Diff.*
1	161	182	13.0	1.40	1.07	-23.6	2076	1747	-15.9	2294	1735	-24.5
2	143	172	20.3	.48	.65	36.0	1494	1703	14.0	1608	1705	6.0
3	247	293	-1.3	4.43	3.31	-25.3	1577	1648	4.5	1567	1574	0.8
4	167	207	24.0	1.78	2.41	35.4	1550	1705	10.0	1412	1611	14.1
5	188	216	15.0	1.18	1.04	-11.8	1324	1435	8.4	1167	1308	11.5
6	129	130	0.8	1.78	1.99	12.2	926	964	4.1	811	754	-7.0
7	257	208	-19.1	1.61	2.08	28.6	2856	234.	-21.4	2313	2207	-4.9
8	214	227	6.1	1.57	1.40	-11.1	1611	1679	4.2	1685	1395	-17.2
9	186	162	-12.9	1.01	.91	-9.9	3586	3496	-0.6	2833	3044	9.4
10	234	245	20.1	1.34	1.44	7.3	1586	1479	-6.7	1253	1252	-0.1

*Percent difference = $\frac{|\text{Chassis} - \text{Stationary}|}{\text{Stationary}} \times 100$

APPENDIX B

LISTING OF INDIVIDUAL RUN RESULTS BY CONTINUOUS NDIR AND CVS (CLOSED CYCLE) ON NINE MODE FTP (CHASSIS VERSION) AND DURING OPERATION ON SAN ANTONIO ROAD ROUTE USING CVS

Table B-1. Truck No. 1, Unit No. 534, 1971 IHC, 345 CID, 6 Cyl, 14,000-lb GVW Van, Source: ABC

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
1-26-72	1	22.72	264	2.26	2771	3.33	39.37	5.21	18.73	127	24.77	7.05
1-31-72	1	20.56	237	2.08	2518	3.20	35.48	4.89	18.19	113	24.22	6.58
Average		21.64	252	2.22	2645	3.27	37.42	5.15	18.46	120	24.50	6.82
Warm Start FTP												
1-26-72	1	20.30	242	2.27	2311	3.31	32.51	4.87	9.75	109	15.80	6.24
1-26-72	2	20.33	306	1.87	2373	3.38	32.39	5.07	9.65	102	15.78	6.29
Average		20.32	274	2.07	2364	3.31	32.55	4.97	9.61	104	15.86	6.26

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
1-27-72	1	Kent	23.78	3.69	46.41	3.99	12.24	153	13.12	10.60	133	11.42	6.30	7.18
1-27-72	2	Kent	18.79	3.45	42.47	4.01	17.64	138	11.59	8.95	109	10.48	5.19	7.39
1-27-72	3	Kent	19.92	3.46	46.27	5.05	18.75	146	15.65	9.53	127	13.66	6.42	7.06
1-27-72	4	Kent	23.05	3.58	51.46	3.67	12.09	178	12.49	11.13	154	10.84	6.67	6.79
1-27-72	5	Bill C.	24.85	2.41	37.66	2.62	9.07	142	9.85	8.82	125	8.78	6.48	7.07
1-27-72	6	Bill C.	24.19	2.36	42.61	4.69	9.61	148	19.46	9.57	135	19.33	7.31	6.27
		Kent Avg.		3.53	46.40	4.24	11.46	151	13.51	10.05	133	11.85		
		Bill C. Avg.		2.64	39.64	3.76	9.34	145	13.12	8.80	132	12.52		
1-28-72	1	Jim C.	19.19	2.94	45.74	5.69	9.93	140	17.39	7.90	121	17.39	6.29	7.22
1-28-72	3	Bob W.	22.60	2.45	42.31	5.52	8.22	139	18.55	7.64	129	17.24	6.73	6.72
1-28-72	4	Jim C.	18.51	3.31	48.92	4.10	9.55	141	17.61	8.45	125	15.99	6.46	7.35
1-28-72	5	Bob W.	20.64	3.12	46.84	5.20	9.45	149	15.76	8.89	139	14.63	6.91	6.94
		Overall Avg.		3.12	44.76	4.63	10.34	145	14.96	9.36	131	13.52	6.52	6.95
		Jim C. Avg.		3.13	47.33	5.90	9.29	141	17.50	8.13	123	15.34		
		Bob W. Avg.		2.79	45.03	5.36	8.84	140	17.24	8.27	134	16.04		

Table B-2. Truck No. 2, 1970 Chevrolet, 350 CID, V-8, 10000-lb GVW Van, Source: E-Z Haul

Date	Run	Time	FTP Concentration HC	CO	NOx	CVS Results Grams per Mile HC	CO	NOx	Grams/lb of Fuel HC	CO	NOx	Fuel wt.
Cold Start FTP												
2-3-72	1	20.41	132	2.24	864	2.28	47.26	2.41	6.28	131	7.35	7.32
2-4-72	1	20.51	133	1.83	1085	1.94	37.75	1.82	5.52	106	5.13	7.27
2-10-72	1	21.37	133	1.47	603	2.08	41.24	2.35	5.93	109	6.25	6.93
2-11-72	1	20.75	117	2.28	603	2.17	42.81	2.38	5.72	111	5.46	7.06
2-13-72	1	21.09	136	2.13	1053	1.78	44.95	2.48	4.95	119	6.40	6.93
Average		20.95	130	2.07	904	2.02	42.61	2.29	5.48	115	6.12	7.16
Warm Start FTP												
2-3-72	1	20.30	155	1.91	2364	2.04	46.40	2.79	7.53	115	7.95	7.02
2-3-72	2	20.30	149	2.35	906	1.92	38.29	2.63	5.65	113	7.77	6.79
2-4-72	2	20.30	137	1.84	2078	1.87	37.24	2.71	5.54	110	8.02	6.76
2-4-72	3	20.30	134	1.92	1132	1.74	31.85	2.69	5.13	105	7.91	6.79
2-10-72	2	20.30	133	1.96	988	1.76	45.37	2.44	6.09	96	5.67	6.92
2-11-72	2	20.30	119	1.97	972	1.99	42.83	2.49	5.48	114	6.84	7.29
Average		20.30	134	1.96	1407	1.94	39.36	2.63	5.57	110	7.34	7.01

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Kilometer HC	CO	NOx	Grams/lb of Fuel HC	CO	NOx	Grams per Mile HC	CO	NOx	Fuel wt.	Miles/gal.
2-9-72	1	Bill C.	19.93	2.65	36.57	2.97	7.33	104	9.54	7.27	106	9.60	7.25	6.25
2-9-72	2	Bob W.	20.09	2.72	36.87	2.92	7.51	105	8.36	7.54	106	8.09	7.27	6.22
2-9-72	3	Kent	19.34	2.61	36.35	3.39	7.47	101	8.99	7.51	102	9.04	7.26	6.21
2-9-72	4	Bill C.	22.10	1.99	41.42	3.06	5.75	119	8.80	6.89	126	9.33	7.67	5.89
2-9-72	5	Kent	21.62	2.52	47.25	2.72	7.31	137	7.92	7.51	140	8.15	7.46	6.17
2-9-72	6	Bob W.	20.76	2.30	42.67	2.59	6.33	118	8.11	6.89	131	8.82	7.67	5.74
		Overall Avg.		2.46	41.27	2.93	6.45	113	8.57	7.14	122	8.94	7.47	6.06
		Bill C. Avg.		2.32	40.00	3.02	6.49	112	9.17	6.98	116	9.47		
		Bob W. Avg.		2.26	40.57	2.76	6.92	112	8.24	7.21	129	8.48		
		Kent Avg.		2.56	42.80	3.05	7.39	121	8.46	7.52	123	8.59		

Table B-3. Truck No. 3, 1972 ISC 304 CID, 8 Cyl., 19,000-lb GTW Van, Source: ABC

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
2-22-72	1	20.49	303	2.36	1459	3.68	32.27	3.24	13.26	116	11.41	5.60
2-23-72	1	21.36	339	2.34	1423	3.61	31.24	2.96	13.59	119	11.25	5.56
Average		20.94	321	2.35	1439	3.65	31.76	3.07	13.40	117	11.33	5.58
Warm Start FTP												
2-17-72	1	20.30	278	2.09	1527	3.05	32.50	3.35	11.49	123	12.66	5.29
2-17-72	2	20.30	264	2.00	1625	2.96	32.15	3.59	11.33	123	13.76	5.22
2-17-72	3	20.30	256	1.95	1648	2.91	31.75	3.65	10.65	116	13.17	5.47
2-23-72	2	20.30	276	2.10	1546	3.22	32.31	3.38	11.74	117	12.17	5.46
Average		20.30	264	2.05	1586	3.03	32.17	3.47	11.30	120	12.94	5.37

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Wt+Fuel
2-23-72	1	Bill C.	21.73	3.37	53.62	2.68	12.96	207	10.31	11.99	191	9.35	6.69	6.76
2-23-72	2	Kent	24.31	3.77	57.80	2.94	13.86	212	9.71	12.62	193	8.94	6.59	6.69
2-23-72	3	Bob W.	23.10	3.68	55.96	2.62	12.28	187	8.69	11.47	172	8.16	6.61	6.69
2-25-72	1	Bill C.	24.24	3.42	49.56	2.40	11.96	172	8.31	11.46	167	8.28	7.48	6.36
2-25-72	2	Kent	23.56	4.46	56.13	2.62	14.93	189	8.81	14.40	183	8.52	7.88	6.46
2-25-72	3	Bob W.	22.23	3.55	53.28	2.56	12.29	184	8.86	11.90	177	8.55	7.78	6.67
2-25-72	4	Bill C.	23.58	4.42	55.47	2.60	13.67	171	8.29	12.63	158	7.66	6.69	6.76
2-25-72	5	Kent	23.74	4.02	59.23	2.56	14.25	204	8.47	13.26	190	7.94	6.77	6.75
2-25-72	6	Bob W.	22.23	4.38	56.50	2.59	14.02	181	8.31	12.27	179	7.90	6.34	7.13
		Overall Avg.		3.94	55.80	2.57	13.02	190	8.73	12.33	177	8.29	6.69	6.69
		Bill C. Avg.		3.74	53.35	2.59	12.57	180	8.77	12.02	172	8.40		
		Kent Avg.		4.38	57.67	2.55	14.35	203	9.00	13.42	192	8.48		
		Bob W. Avg.		3.72	48.25	2.59	12.15	157	8.62	11.55	165	8.34		

Table B-4. Truck No. 4, 1978 Ford, 360 CID, 6 Cyl., 10,000-lb GVW, Van, Source: Hertz

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
3-13-72	1	23.77	145	5.45	3000	1.62	7.81	5.69	7.54	34.42	32.45	5.03
3-13-72	1	23.75	133	5.31	3063	1.72	6.23	6.79	7.07	25.44	27.66	4.06
3-16-72	1	23.61	165	5.36	2907	1.73	5.35	5.89	7.22	22.29	24.54	4.04
Average		23.61	154	5.36	2990	1.76	6.45	6.23	7.28	24.04	28.23	5.03
Warm Start FTP												
3-13-72	2	23.80	149	5.34	3067	1.79	3.75	5.81	7.49	23.70	24.37	4.78
3-13-72	3	23.80	164	5.27	3292	1.64	3.54	6.60	7.80	16.93	24.10	4.81
3-13-72	2	23.80	140	5.26	3160	1.65	3.48	7.26	6.59	16.39	29.62	4.42
3-16-72	2	23.37	152	5.27	3063	1.65	3.57	5.77	6.83	16.75	23.89	4.99
Average		23.1	163	5.29	3101	1.64	3.58	6.24	7.34	16.87	25.47	4.82

SKY ANCONED ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
3-14-72	1	Kent	24.14	1.47	16.28	5.52	5.76	63.47	21.62	4.90	54.00	18.39	6.24	7.36
3-14-72	2	Bill C.	24.33	1.59	14.62	5.45	6.29	64.45	20.69	5.34	56.53	18.33	6.35	7.12
3-7-72	1	Bill C.	23.26	2.81	30.51	4.94	6.53	99.39	24.06	5.61	85.39	13.81	6.22	7.27
3-7-72	2	Kent	22.14	1.80	29.52	4.65	5.41	135.24	16.57	5.50	96.27	14.21	6.21	7.28
3-7-72	3	Bob W.	23.23	1.77	30.36	4.96	5.79	96.42	16.29	4.93	83.89	13.89	6.17	7.33
3-7-72	4	Bill C.	22.36	1.71	30.35	4.79	6.24	108.37	16.91	5.21	90.59	14.66	6.25	7.26
3-7-72	5	Kent	21.53	1.69	31.46	4.80	5.88	109.17	16.67	5.26	93.96	14.36	6.23	7.25
3-7-72	6	Bob W.	22.42	1.65	31.53	4.85	6.04	114.39	17.60	5.67	97.63	15.02	6.28	7.32
3-13-72	1	Ernie D.	19.34	1.36	19.58	6.76	4.60	66.24	22.90	3.57	51.50	17.77	5.62	8.05
3-16-72	1	Kent	23.83	1.42	21.62	4.89	5.03	77.41	17.34	4.26	62.77	14.06	5.87	7.78
3-16-72	3	Bob W.	21.46	1.47	22.35	4.52	5.19	78.97	23.85	4.35	61.21	19.33	6.07	7.45
3-16-72	4	Kent	22.24	1.53	23.40	4.96	5.76	76.74	18.57	4.78	62.75	15.19	5.92	7.54
3-16-72	5	Ernie D.	21.28	1.47	21.22	6.68	5.99	76.04	27.99	4.91	62.36	19.69	5.94	7.41
		Overall Avg.		1.64	24.73	5.37	5.62	97.39	17.11	4.91	73.75	16.69	6.09	7.40
		Kent Avg.		1.58	23.69	4.96	5.76	86.46	18.15	4.85	72.75	15.26		
		Bill C. Avg.		1.77	25.75	5.26	6.22	89.97	17.96	5.39	77.62	15.59		
		Bob W. Avg.		1.69	27.98	5.45	5.87	97.26	19.99	4.98	62.83	16.87		
		Ernie D. Avg.		1.52	20.46	6.72	5.29	72.19	25.40	4.24	56.96	18.72		

Table B-5. Truck No. 5, 1970 Chevrolet, 350 CID, V-8, 10,000-lb GVW Van, Source: E-Z Haul

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
3-26-72	1	21.78	286	2,117	714	3.04	42.67	1.15	6.84	126	4.21	7.42
3-27-72	1	22.79	295	2,157	598	3.06	43.15	1.65	10.59	132	5.05	6.79
3-28-72	1	21.34	258	2,227	634	3.53	45.55	1.79	10.46	134	5.33	7.22
Average		21.97	234	2,178	645	3.34	42.12	1.63	9.96	125	4.86	7.14
Warm Start FTP												
3-26-72	2	22.00	179	2,154	755	2.54	42.00	2.15	7.40	123	4.48	6.47
3-26-72	3	22.00	159	1,952	756	2.50	39.88	2.22	7.31	115	4.49	6.85
3-27-72	2	22.00	264	2,382	645	3.26	45.93	1.66	9.19	129	5.19	6.48
3-28-72	2	22.00	252	2,154	660	2.99	39.39	1.65	9.26	122	5.72	6.47
Average		22.00	213	2,186	704	2.82	42.29	1.99	8.49	122	5.97	6.61

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
3-27-72	1	Bill C.	42.31	3.29	63.31	2.45	9.51	184	7.24	9.85	195	7.42	7.59	6.69
3-27-72	2	Kent	21.68	2.47	46.49	2.81	7.77	153	6.34	7.39	145	6.62	6.88	6.57
3-28-72	1	Bill C.	20.88	4.66	97.58	2.42	12.60	264	6.56	13.40	269	7.08	7.72	5.98
3-28-72	2	Kent	21.33	3.38	61.72	2.53	11.38	191	7.62	10.46	197	7.36	6.83	6.62
3-28-72	3	Bob W.	22.20	3.19	57.86	2.62	9.62	178	6.28	9.79	177	6.19	7.22	6.28
3-29-72	1	Bill C.	23.45	2.39	52.66	3.31	6.92	152	9.63	6.73	148	9.36	7.34	6.45
3-29-72	2	Kent	19.97	2.38	55.77	3.79	6.45	157	10.62	6.33	154	10.45	7.11	6.36
3-29-72	3	Bob W.	21.42	2.11	51.92	3.67	6.12	150	10.62	6.23	154	10.85	7.46	6.11
3-29-72	4	Bill C.	22.27	2.38	55.39	3.29	6.78	158	9.39	7.31	170	10.13	7.48	5.72
3-29-72	5	Kent	19.42	1.98	51.81	3.65	5.29	139	10.28	5.30	139	10.28	7.28	6.25
3-29-72	6	Bob W.	21.53	1.96	54.51	3.26	6.37	177	10.55	5.82	162	9.69	6.62	6.65
		Overall Avg.	2.75	56.40	2.96	6.86	194	8.04	8.36	193	8.41	7.22		
		Bill C. Avg.	3.26	57.24	2.86	5.93	203	8.26	9.33	178	8.48	7.54		
		Kent Avg.	2.58	56.74	3.34	7.65	267	8.77	7.37	261	8.53	7.02		
		Bob W. Avg.	2.42	54.77	2.99	7.46	268	9.12	7.29	264	8.69	7.26		

Table B-6. Truck No. 6, 1970 Ford, 360 CID V-8, 24,000-lb GVW Van, Source Ryder

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
4-6-72	1	23.71	381	5.61	2130	3.65	27.98	5.03	22.25	63.82	27.63	5.81
4-11-72	1	23.40	282	8.93	2878	3.94	29.42	5.62	18.94	65.63	29.86	6.24
Average		23.60	292	8.67	2703	3.77	28.84	5.33	13.13	64.62	28.58	5.99
Hyper Start FTP												
4-5-72	2	23.30	254	5.63	2155	3.36	23.04	5.27	12.68	46.21	19.25	5.34
4-5-72	3	23.30	255	5.65	2176	3.26	22.67	5.09	12.28	47.92	18.96	5.27
4-11-72	2	23.65	286	6.75	2464	3.81	26.96	5.26	20.54	59.67	18.28	5.65
Average		23.30	265	5.68	2264	3.22	24.26	5.12	12.39	52.57	19.82	5.39

SAT ARTERIAL ROAD ROUTE

Date	Run	Driver	Time	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
4-6-72	1	Bill C	21.40	1.29	45.45	1.71	14.27	125	15.72	65.33	134	26.89	7.79	5.61
4-6-72	2	Kent	23.26	1.36	47.36	1.50	14.54	124	14.39	15.48	131	15.25	7.67	5.69
4-6-72	3	Bob	23.31	4.78	42.07	1.34	13.78	121	14.51	13.42	119	14.13	7.05	6.42
4-7-72	1	Bill	21.26	6.72	50.51	1.41	16.98	128	13.66	19.73	149	15.87	8.42	5.78
4-7-72	2	Kent	20.51	6.34	47.94	1.40	18.28	139	15.96	17.95	136	15.38	7.11	6.36
4-7-72	3	Bob	20.61	6.80	54.76	1.23	24.48	142	14.26	17.25	145	14.95	7.54	5.96
4-7-72	4	Bill	23.05	5.04	37.54	1.30	14.62	139	14.68	16.95	138	26.18	7.96	5.69
4-10-72	1	Bill	25.25	5.06	43.76	4.73	14.43	126	13.64	17.78	153	26.51	9.76	5.26
4-10-72	2	Kent	22.69	5.53	45.68	4.64	15.49	122	13.51	17.32	137	25.13	8.22	5.57
4-10-72	3	Bob	25.40	4.48	42.54	4.29	12.92	114	12.97	17.29	153	24.58	9.69	5.06
4-10-72	4	Bill	22.62	5.78	44.62	5.36	15.29	119	14.36	17.81	133	26.81	8.06	5.64
4-10-72	5	Kent	23.45	5.40	47.51	5.72	14.55	128	15.32	17.99	155	28.51	8.75	5.17
4-10-72	6	Bob	22.90	4.84	37.44	4.61	12.11	94	12.05	14.65	117	24.58	8.76	5.24
		Overall Avg.		5.47	44.64	5.23	14.91	122	24.35	26.67	137	25.69	8.05	5.60
		Bill Avg.		5.25	44.37	5.24	15.31	131	14.42	27.34	139	26.29	8.23	
		Kent Avg.		5.72	46.72	5.37	15.71	129	14.72	27.87	140	26.37	7.91	
		Bob Avg.		5.24	42.78	4.61	13.57	124	12.95	25.65	139	24.99	8.02	

Table B-7. Truck No. 7, 1970 GMC, 351 CID, 6 Cyl., 19,500-lb GVW Stake, Source: DOT Metal

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
4-17-72	1	22.67	419	1.48	588	7.74	60	0.99	24.26	275	3.39	6.66
4-18-72	1	23.67	490	4.09	464	6.94	63	0.71	24.95	283	2.40	6.68
Average		23.17	455	1.79	481	6.34	62	0.85	24.61	279	2.91	6.36
Warm Start FTP												
4-17-72	2	23.00	477	1.63	587	4.59	76	0.97	24.46	272	3.38	5.59
4-17-72	3	23.00	464	4.04	540	4.56	63	0.98	24.19	260	3.47	5.63
4-17-72	4	23.00	453	4.12	544	4.60	65	0.95	24.17	255	3.36	5.69
4-18-72	2	23.00	467	4.28	565	4.48	60	1.75	25.85	288	2.65	5.62
Average		23.00	472	4.02	565	4.55	61	0.96	24.24	280	3.19	5.62

SAE ARTICHOKE ROAD ROUTE

Date	Run	Driver	Time	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Time (hr)
4-19-72	1	Bill C.	21.83	5.59	234	1.23	26.38	385	3.59	26.86	315	3.72	7.49	6.36
4-19-72	3	Bob W.	21.85	6.38	81	0.78	29.61	248	2.26	29.25	266	2.12	7.11	6.36
4-20-72	1	Bill C.	23.63	5.55	159	1.59	24.74	286	4.22	25.78	307	4.52	7.75	5.62
4-20-72	2	Kent	19.75	5.68	97	1.36	26.40	271	3.81	26.84	265	2.96	7.09	6.39
4-24-72	1	Bill C.	23.68	6.62	92	1.55	28.52	276	4.66	22.35	308	5.07	7.87	5.74
4-24-72	2	Ernie K.	22.32	6.70	93	1.22	28.91	226	3.77	28.65	286	3.77	7.25	6.32
4-24-72	3	Bob W.	21.48	6.31	232	1.73	28.79	724	5.39	27.89	303	5.13	6.69	6.36
4-24-72	4	Bill C.	21.12	5.76	99	1.25	25.90	272	3.46	24.97	266	3.65	7.58	5.69
4-24-72	5	Ernie K.	20.92	5.82	97	1.26	27.96	302	3.90	24.80	262	3.54	6.77	6.69
		Overall Avg.	6.01	91	1.29	27.90	285	3.79	24.55	289	3.84	7.30		
		Bill C. Avg.	5.94	101	1.41	26.87	281	3.99	27.95	303	4.24	7.70		
		Bob W. Avg.	6.02	92	1.22	29.20	263	3.78	28.57	274	3.63	7.80		
		Kent Avg.	5.68	97	1.36	26.40	271	3.81	26.84	265	2.96	7.09		
		Ernie K. Avg.	5.82	97	1.26	27.96	302	3.90	24.80	262	3.54	6.77		

Table B-8. Truck No. 8, 1972 Ford, 391 CID, 8 Cyl, 27,500-lb GVW Van, Source: Grumbo Ford Rental

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold-Start FTP												
4-27-72	1	21.78	373	1.40	1779	5.57	34.09	4.57	24.95	154	19.91	7.23
4-28-72	1	21.22	348	1.24	1859	5.46	31.80	3.89	24.82	94	17.45	7.28
5-4-72	1	21.40	334	1.21	1919	4.92	28.72	4.77	24.92	87	24.48	7.22
Average		21.54	352	1.28	1852	5.31	31.54	4.41	25.56	111	23.28	7.25
Warm-Start FTP												
4-27-72	2	20.00	327	1.32	1909	5.02	31.45	4.96	25.90	108	25.72	6.31
4-27-72	3	20.00	261	1.29	1948	4.71	29.50	5.78	24.37	90	27.65	6.55
4-27-72	4	20.00	296	1.30	2022	4.69	29.36	5.39	24.89	93	27.11	6.38
4-28-72	2	20.00	268	1.26	2024	4.49	29	3.77	24.11	95	21.65	6.27
5-4-72	2	20.00	313	1.25	2064	4.34	26.94	5.05	23.20	92	25.35	6.98
Average		20.00	293	1.27	2001	4.61	29.29	4.99	24.49	92	25.53	6.42

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
5-1-72	1	Driver E.	22.40	10.36	67.02	3.95	24.99	162	9.53	30.40	204	11.78	6.95	5.05
5-1-72	2	Driver D.	22.38	9.49	64.15	4.11	24.51	163	10.48	28.87	196	12.72	6.80	5.24
5-1-72	3	Bob W.	23.42	9.69	59.11	4.14	23.94	154	11.41	28.56	179	13.52	6.40	5.35
5-1-72	4	Driver E.	22.94	10.23	75.66	4.23	25.98	192	10.72	31.91	229	12.80	6.67	5.21
5-1-72	5	Driver D.	24.60	9.78	64.50	4.20	23.88	157	10.23	25.58	176	11.45	6.23	5.56
5-1-72	6	Bob W.	23.47	9.14	60.11	4.26	23.11	148	10.52	26.64	162	12.06	6.93	5.35
5-2-72	1	Driver E.	22.59	8.80	68.23	3.87	22.85	177	10.01	26.37	203	11.53	6.36	5.42
5-2-72	2	Driver D.	22.37	7.99	66.33	4.28	20.54	170	10.99	23.26	192	12.45	6.20	5.51
5-4-72	1	Driver E.	22.95	8.79	65.97	4.06	21.65	164	11.59	24.64	188	14.14	4.82	5.12
5-4-72	2	Driver D.	22.34	7.60	58.74	4.64	20.24	156	14.94	23.49	181	14.94	6.39	5.39
5-4-72	1	Driver E.	22.85	7.23	56.20	4.73	20.49	161	13.49	21.53	171	14.28	7.61	5.56
5-4-72	2	Bob W.	23.56	6.56	54.46	4.42	17.35	145	11.81	18.59	154	12.81	6.36	5.61
		Overall Avg.		7.42	62.96	4.10	19.42	162	11.40	22.91	189	12.74	6.46	
		Driver E. Avg.		9.07	66.57	4.28	23.22	171	11.07	27.29	200	12.69	6.40	
		Driver D. Avg.		6.95	63.36	4.36	17.79	162	11.66	20.49	167	12.90	6.39	
		Bob W. Avg.		6.13	56.56	4.28	19.01	148	11.44	19.72	173	13.10	6.47	

TABLE B-4. Truck No. 4, 1972 Ford, 330 CID V-8, 24,000-lb GVW Van, Sourced: Ryder

			FTP Concentration			CVS Results Grams per Mile			Grams/lb of Fuel			
Date	Run	Time	HC	CO	NO	HC	CO	NO_x	HC	CO	NO_x	Fuel wt.
Cold Start FTP												
1-6-72	1	21.94	301	1.75	2326	3.70	17.92	4.71	12.65	58.24	15.10	4.15
1-10-72	1	20.47	323	1.65	2403	4.06	19.36	3.79	13.93	65.36	19.86	5.97
1-13-72	1	21.01	264	1.75	2324	3.74	24.62	5.03	12.75	64.96	17.10	4.28
Average		21.14	297	1.78	2326	3.83	24.30	5.18	13.10	62.52	17.69	4.10
Warm Start FTP												
1-12-72	2	20.10	246	1.61	2342	3.02	14.34	3.02	11.14	56.97	16.72	5.42
1-12-72	3	20.00	264	1.74	2465	3.23	15.70	4.92	11.28	56.46	17.69	5.56
1-24-72	2	20.00	259	1.76	2362	2.95	15.23	5.23	10.73	55.36	19.36	5.50
1-25-72	3	20.01	246	1.71	2521	2.70	14.40	5.33	9.85	53.27	19.45	5.49
Average		20.03	254	1.77	2423	2.96	15.20	4.61	10.76	55.52	18.40	5.49

SAN ANTONIO ROAD ROUTE

				Grams per Mile			Grams/lb of Fuel			Grams per Mile				
Date	Run	Driver	Time	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x	Fuel wt.	Mileage
1-10-72	1	Ernie K.	22.01	4.61	47.19	4.10	29.43	296	22.61	22.31	149	12.82	7.49	5.78
1-10-72	2	Ernie D.	19.69	4.11	40.94	4.23	24.61	243	23.36	20.66	217	21.30	7.53	5.81
1-24-72	3	Bob W.	20.29	4.13	40.43	4.79	25.90	259	22.44	17.37	226	23.35	7.77	5.62
1-25-72	1	Ernie D.	20.30	4.96	40.23	4.46	23.56	231	22.79	23.41	221	22.46	7.27	6.22
1-26-72	4	Bob W.	21.22	5.72	42.30	5.02	26.05	232	24.07	27.49	231	25.36	7.69	5.73
1-27-72	1	Ernie K.	21.31	4.35	43.26	4.29	24.65	227	21.90	27.81	227	22.62	7.99	5.92
1-27-72	2	Ernie D.	20.29	5.42	42.39	4.46	24.70	224	22.22	25.29	228	22.46	7.27	6.24
1-27-72	3	Bob W.	19.47	5.46	42.69	5.25	24.38	220	23.38	25.22	224	24.76	7.62	5.99
		Overall Avg.		4.38	43.14	4.59	25.92	229	22.46	24.79	224	23.07	7.62	
		Ernie K. Avg.		4.48	45.22	4.23	27.24	126	22.02	28.25	233	22.63	7.62	
		Ernie D. Avg.		5.48	42.58	4.77	24.63	227	22.69	25.25	224	22.47	7.47	
		Bob W. Avg.		5.77	42.24	4.79	25.44	223	23.25	26.36	232	25.02	7.76	

Table B-10. Truck No. 10, 1972 Ford, 361 CID V-8, 19,200-lb GVW Van, Source: Keebler Co.

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	CVS Results Grams per Mile CO	CVS Results Grams per Mile NO_x	CVS Results Grams/lb of Fuel HC	CVS Results Grams/lb of Fuel CO	CVS Results Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
1-26-72	1	21.30	226	3.44	2281	2.90	23.91	3.23	4.39	75.27	9.62	6.69
1-26-72	1	21.13	229	4.73	2249	3.34	34.24	3.75	4.55	97.69	11.78	6.73
1-26-72	1	21.13	233	4.76	2345	2.90	25.69	3.48	4.62	47.74	26.64	7.01
Average			229	4.71	2272	2.95	28.09	4.22	4.25	57.87	12.76	6.81
Warm Start FTP												
1-26-72	2	20.30	730	4.44	2210	2.25	23.22	4.59	7.46	40.27	25.92	6.11
1-26-72	2	20.30	229	3.52	2262	2.12	26.96	5.03	4.28	48.50	24.66	6.85
1-26-72	2	20.30	228	3.54	2277	2.46	23.36	5.24	4.54	46.72	28.32	5.72
1-26-72	2	20.30	231	3.44	2298	2.52	23.53	5.85	4.28	44.80	24.92	6.25
Average			229	3.44	2270	2.34	24.27	5.29	7.58	45.87	24.75	6.32

TWO ARTERIAL ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
1-26-72	2	E.D.	21.47	3.13	47.59	4.45	23.38	252	24.89	4.27	142	13.98	6.71	6.74
1-26-72	2	I.S.	19.24	4.42	62.35	4.24	23.88	256	19.78	24.45	342	11.18	7.51	6.52
1-26-72	2	L.B.	22.48	4.74	46.34	3.44	22.29	229	24.95	24.88	236	26.67	6.28	5.46
1-26-72	3	E.D.	19.37	4.99	57.25	3.97	23.47	259	19.72	23.34	253	19.—	7.27	6.31
1-26-72	3	E.D.	19.46	3.96	42.46	4.75	24.51	225	23.12	19.24	206	22.21	6.68	6.77
1-26-72	2	I.S.	19.37	5.77	64.62	4.32	24.38	256	23.54	24.39	242	19.77	7.48	6.11
1-26-72	3	L.B.	22.56	4.32	62.56	4.62	22.42	225	22.96	23.67	251	25.29	6.52	6.32
1-26-72	4	I.S.	22.27	5.79	52.45	3.42	26.73	252	20.46	26.96	244	27.42	7.35	6.26
		Overall Avg.		4.77	52.43	4.47	22.88	240	22.24	23.26	246	22.54	7.40	6.11
		L.B. Avg.		4.53	44.35	3.23	24.75	227	23.50	23.84	236	25.86	6.40	
		E.D. Avg.		4.03	49.75	4.46	23.49	242	22.91	20.92	233	22.27	6.89	
		I.S. Avg.		4.64	58.27	4.04	24.10	234	19.97	25.26	259	25.43	7.42	

Table B-11. Truck No. 11, 1973 Dodge, 318 CID, V-8, 24,000-lb GVW Van, Source: Red Arrow

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
4-4-72	1	20.8	352	1.45	2669	4.29	27.96	3.55	14.60	95.45	12.11	4.23
4-5-72	1	21.37	384	1.43	1724	4.43	26.97	3.37	15.26	92.94	11.60	4.21
4-13-72	1	21.08	352	1.59	1842	4.32	27.34	3.55	14.85	94.03	12.17	4.24
4-13-72	1	21.09	358	1.49	2653	4.48	28.12	3.51	15.42	96.78	12.14	4.23
Average		21.18	363	1.47	1720	4.38	27.94	3.50	15.03	94.64	12.01	4.23
Warm Start FTP												
4-4-72	2	20.00	337	1.50	1986	3.42	27.77	4.22	11.93	94.72	14.39	5.65
4-4-72	3	20.28	320	1.49	1941	3.27	27.52	4.21	11.83	98.23	15.02	5.61
4-5-72	2	20.00	324	1.52	1931	3.51	29.36	4.37	12.21	102.00	15.24	5.74
4-13-72	2	20.00	338	1.51	1933	3.43	29.61	4.25	11.86	99.53	14.68	5.75
4-13-72	2	20.00	326	1.52	1944	3.59	29.35	4.28	12.48	102.00	14.54	5.75
Average		20.00	323	1.51	1925	3.46	28.50	4.25	12.05	99.09	14.77	5.75

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Miles/gal.
4-13-72	1	T.S.	19.03	5.87	93.37	4.10	24.09	146	11.26	26.36	146	11.24	7.23	6.25
4-13-72	2	L.B.	19.72	5.78	90.27	4.60	24.87	129	12.25	25.73	127	13.07	7.64	5.90
4-13-72	3	B.W.	20.97	5.29	91.94	4.09	24.74	144	11.46	25.29	150	11.80	7.51	6.02
4-14-72	1	L.B.	20.52	5.50	86.90	4.27	24.38	122	11.89	25.60	133	12.10	7.90	5.72
4-14-72	2	T.S.	20.34	6.85	91.79	3.96	28.69	140	13.54	29.26	144	13.85	7.46	6.06
4-14-72	3	B.W.	20.20	5.31	88.53	3.59	24.95	129	11.47	24.84	127	11.37	7.24	6.20
4-14-72	4	L.B.	19.78	4.77	82.23	4.32	20.59	152	18.57	18.49	179	11.78	6.97	5.60
4-14-72	5	T.S.	21.40	6.40	95.81	3.36	28.24	159	17.13	28.92	165	10.95	7.54	6.00
4-14-72	6	B.W.	22.19	5.13	90.36	3.74	24.81	140	10.81	25.65	150	11.42	7.61	5.91
		Overall Avg.		5.67	91.82	4.39	25.91	141	11.37	26.44	147	11.59	7.56	5.97
		T.S. Avg.		6.37	93.71	3.94	27.79	140	12.44	28.38	152	12.88	7.41	
		L.B. Avg.		5.02	93.13	4.46	25.25	134	11.34	26.42	156	11.92	7.68	
		B.W. Avg.		5.21	88.91	3.96	24.83	139	11.23	25.26	140	11.54	7.45	

TABLE B-12 Truck No. 12, 1972 [illegible], 145 CID V-8, 25,000-lb GVW Van, Source: ABC

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
4-29-72	1	23.91	224	1.48	1287	3.79	27.67	2.15	13.83	95	6.79	6.87
4-29-72	1	23.93	234	1.19	1146	3.13	23.09	2.13	11.91	80	7.92	5.64
4-30-72	1	23.98	240	1.23	1454	3.28	23.97	2.68	11.58	94	9.11	5.98
Average		23.94	233	1.27	1294	3.40	24.91	2.40	12.44	89	8.01	5.90
Warm Start FTP												
4-29-72	2	23.93	223	1.49	1473	3.64	27.49	2.47	12.88	96	9.23	5.68
4-29-72	2	23.93	247	1.23	1223	3.23	25.62	2.13	11.91	85	7.82	5.38
4-30-72	2	23.93	245	1.23	1351	3.22	25.25	2.67	11.13	90	10.25	5.61
Average		23.93	238	1.32	1349	3.36	26.25	2.47	11.97	94	9.10	5.56

SAE JUSTICED ROAD ROUTE

Date	Run	Driver	Time	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per MDx HC	Grams per MDx CO	Grams per MDx NO_x	Fuel wt.	MDwt./gal.
4-27-72	1	L.R.	28.12	5.01	69.24	2.69	14.45	177	6.88	15.69	192	7.46	7.69	5.75
4-27-72	2	L.R.	28.40	6.57	82.04	3.00	15.22	189	6.96	15.72	209	7.78	8.01	5.64
4-27-72	1	L.S.	22.87	5.86	73.71	2.23	15.04	197	5.96	18.42	233	7.03	8.17	5.29
4-27-72	2	R.W.	30.26	5.47	75.45	2.31	15.72	199	6.08	16.80	223	6.70	7.74	5.84
4-28-72	1	L.R.	22.79	4.32	79.75	2.45	17.35	224	6.54	19.22	240	7.49	8.23	5.54
4-28-72	2	R.W.	24.11	5.26	69.24	2.17	13.40	179	5.52	14.23	187	5.85	7.64	5.89
4-27-72	1	L.S.	24.27	4.56	76.34	2.46	14.44	186	6.07	16.17	202	6.40	7.88	5.74
4-27-72	2	L.R.	24.91	6.92	90.24	2.79	17.33	232	6.47	18.29	240	7.32	8.04	5.26
4-27-72	1	R.W.	28.67	5.72	72.60	2.40	14.47	187	6.27	15.48	204	7.01	7.97	5.67
	Overall Avg.			4.94	79.46	2.51	15.27	202	6.29	16.49	214	7.00	8.05	5.62
	L.R. Avg.			4.36	80.54	2.74	15.49	196	6.66	17.45	221	7.49	8.24	
	L.S. Avg.			5.47	74.52	2.34	15.25	192	6.01	17.54	218	6.92	8.23	
	R.W. Avg.			5.64	72.28	2.36	14.78	187	6.34	15.93	202	6.85	7.90	

Table B-13. Truck No. 13, 1978 [illegible] 304 CID, V-8, 17,000-lb GVW Van, Source: [illegible]

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	CVS Results Grams per Mile CO	CVS Results Grams per Mile NO_x	CVS Results Grams/lb of Fuel HC	CVS Results Grams/lb of Fuel CO	CVS Results Grams/lb of Fuel NO_x	Fuel Mileage
Cold Start FTP												
7-12-72	1	21.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	1	20.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-14-72	1	21.58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average		20.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Warm Start FTP												
7-12-72	2	20.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	2	21.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	2	20.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-14-72	2	20.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average		20.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Minute HC	Grams per Minute CO	Grams per Minute NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel Mileage	Miles per Gallon
7-12-72	3	E.D.	22.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	3	R.C.	20.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	4	E.D.	21.09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	3	L.B.	19.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	2	L.B.	19.69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-13-72	3	R.C.	19.96	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-14-72	3	E.D.	20.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-14-72	2	L.B.	22.43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Overall Avg.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		E.D. Avg.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		L.B. Avg.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		R.C. Avg.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		L.B. Avg.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Table B-14. Truck No. 14, 1972 IHC, 345 CID, V-8, 24,500-lb GVW Van, Source: ABC

Date	Run	Time	FTP Concentration HC	FTP Concentration CO	FTP Concentration NO_x	CVS Results Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/lb of Fuel HC	Grams/lb of Fuel CO	Grams/lb of Fuel NO_x	Fuel wt.
Cold Start FTP												
7-24-72	1	21.92	274	1.20	1462	3.35	29.39	2.79	10.91	96	9.09	4.45
7-25-72	1	21.90	262	1.12	1298	3.39	25.76	2.89	10.48	87	8.29	4.42
7-27-72	1	21.98	285	1.09	1355	3.29	26.14	2.76	10.94	89	9.16	4.52
Average		21.92	290	1.14	1349	3.34	27.10	2.81	10.74	90	8.85	4.46
Warm Start FTP												
7-24-72	1	21.90	270	1.21	1332	3.31	29.36	2.91	10.24	96	9.82	4.43
7-26-72	2	21.10	267	1.22	1386	3.39	29.50	3.09	10.36	99	10.34	4.47
7-26-72	2	20.90	279	1.21	1343	3.39	27.72	2.46	10.20	93	8.22	4.43
7-25-72	2	22.00	273	1.23	1388	3.91	29.27	2.92	9.96	96	10.04	4.62
7-27-72	2	20.80	274	1.23	1378	3.77	29.34	2.91	9.29	94	9.66	4.33
Average		21.34	273	1.24	1329	3.46	27.46	2.85	9.96	92	9.62	5.34

SAN ANTONIO ROAD ROUTE

Date	Run	Driver	Time	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Grams/Lb of Fuel HC	Grams/Lb of Fuel CO	Grams/Lb of Fuel NO_x	Grams per Mile HC	Grams per Mile CO	Grams per Mile NO_x	Fuel wt.	Wind spd.
7-24-72	1	E.D.	22.46	3.60	50.40	2.62	9.44	240	7.96	10.55	294	8.73	7.92	5.71
7-24-72	2	L.B.	23.02	4.55	57.79	2.53	11.23	236	5.86	13.52	264	7.21	8.77	5.29
7-24-72	3	R.C.	22.50	4.28	52.94	2.27	11.76	244	6.33	13.38	260	7.36	8.58	5.60
7-25-72	2	R.C.	20.90	4.49	49.36	2.36	11.42	232	5.91	13.99	240	6.22	7.90	5.73
7-26-72	1	E.D.	22.40	3.67	46.89	1.79	10.40	242	5.58	10.86	245	5.72	7.42	6.25
	Overall Avg.			4.31	51.41	2.31	11.24	239	6.27	12.35	254	6.97	8.02	5.66
	E.D. Avg.			3.94	49.44	2.36	10.22	242	6.78	10.71	251	7.23	7.87	
	L.B. Avg.			4.75	57.79	2.10	11.23	236	5.86	13.52	264	7.21	8.77	
	R.C. Avg.			4.89	50.47	2.24	11.27	238	5.92	13.40	252	6.59	7.99	

APPENDIX C

VEHICLE-ENGINE OPERATING PERFORMANCE DATA SUMMARIES FOR TRUCKS OPERATED OVER SAN ANTONIO ROAD ROUTE COMPUTER PRINT-OUTS

ENGINE AND VEHICLE PERFORMANCE
S. A. R. R. TRUCK 1

1971 IHC 16,000 LB GVW VAN
WITH 345 CID V8 ENGINE

1/03/19 TR NO: 500 = 005 CID 007 RR RUN NO: 1 TIME 1700

VAR NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE
000 1	1715.7303	557.0917	6.1565	11500	3965.0000	525.0000	3440.0000
00 4	15.7300	6.5705	.0607	11500	25.9750	0.0000	25.9750
000 5	10.4429	10.7770	.1005	11500	50.6667	0.0000	50.6667
TO 5	.0965	.0735	.0007	11500	.1900	-.0020	.1920

PERCENT OF TIME
000 AT
LEVEL COUNT PERCENT

#		
500 < 600	4	.04
600 < 800	187	1.70
800 < 1000	1587	14.80
1000 < 1200	950	8.91
1200 < 1400	826	7.63
1400 < 1600	2049	17.82
1600 < 1800	1815	15.05
1800 < 2000	1348	10.33
2000 < 2200	876	7.64
2200 < 2400	961	8.37
2400 < 2600	704	6.05
2600 < 2800	466	3.89
2800 < 3000	119	1.03
3000 < 3200	71	.58
3200 < 3400	36	.31
3400 < 3600	05	.04

PERCENT OF TIME 000 AT
LEVEL COUNT PERCENT

#		
1	5	.04
2	705	06.51
3	859	09.15
4	1895	12.85
5	0	0.00

PERCENT OF TIME 00 AT
LEVEL COUNT PERCENT

#		
0 < 1	50	.39
1 < 2	1138	1.90
2 < 3	1320	1.61
3 < 4	1207	1.43
4 < 5	1111	1.34
5 < 6	1100	1.12
6 < 7	1200	1.10
7 < 8	1204	1.07
8 < 9	1015	1.01
9 < 10	1047	1.10
10 < 11	1137	10.07
11 < 12	1103	10.01
12 < 13	1010	1.15
13 < 14	0	0.00
14 < 15	0	0.00
15 < 16	0	0.00
16 < 17	0	0.00
17 < 18	0	0.00
18 < 19	0	0.00
19 < 20	0	0.00
20 < 21	0	0.00
21 < 22	0	0.00
22 < 23	0	0.00
23 < 24	0	0.00
24 < 25	0	0.00
25 < 26	0	0.00
26 < 27	0	0.00
27 < 28	0	0.00
28 < 29	0	0.00
29 < 30	0	0.00
30 < 31	0	0.00
31 < 32	0	0.00
32 < 33	0	0.00
33 < 34	0	0.00
34 < 35	0	0.00
35 < 36	0	0.00
36 < 37	0	0.00

PERCENT OF TIME 00 AT
LEVEL COUNT PERCENT

#		
0 < 1	1014	10.01
1 < 2	210	1.10
2 < 3	011	1.03
3 < 4	104	1.00
4 < 5	013	1.10
5 < 6	020	1.09
6 < 7	001	1.07
7 < 8	011	1.11
8 < 9	1020	10.10
9 < 10	025	1.13
10 < 11	210	1.10
11 < 12	1301	12.01
12 < 13	1004	1.03
13 < 14	010	1.00
14 < 15	001	1.07
15 < 16	102	1.09
16 < 17	111	1.01
17 < 18	105	1.10
18 < 19	215	1.13
19 < 20	208	1.10
20 < 21	208	1.10
21 < 22	57	1.00
22 < 23	0	0.00
23 < 24	0	0.00
24 < 25	0	0.00
25 < 26	0	0.00
26 < 27	0	0.00
27 < 28	0	0.00
28 < 29	0	0.00
29 < 30	0	0.00
30 < 31	0	0.00
31 < 32	0	0.00
32 < 33	0	0.00
33 < 34	0	0.00
34 < 35	0	0.00
35 < 36	0	0.00
36 < 37	0	0.00

[illegible]

1/27/10 TO 00: 000 = 000 EID DAT OR RUN 00: 0 TIME LINE

1/07/78 IN HD, SAS - BAS CIS BAT BR RUN HD, S TIME 1855

ENGINE AND VEHICLE PERFORMANCE
S. A. B. B. TRUCK 1

1970 CHEVROLET 18,000 LB GVW VAN
WITH 350 CID V8 ENGINE

ENGINE AND VEHICLE PERFORMANCE
S.A.R.R. TRUCK 3

1974 IHC 19,000-LB GVW VAN
WITH 304 CID V-8 ENGINE

DATA FOR TRUCK 3
BEING PROCESSED

ENGINE AND VEHICLE PERFORMANCE
S.A.B.R. TRUCK 48

1970 FORD 10,000-LB GVW VAN
WITH 300 CID I-6 ENGINE

[illegible]

VAR	NO	MEAN	S.D.	S.E. OF MEAN	SAMPLE MAXIMUM	MINIMUM	RANGE
RPM	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MV	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GEAR	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TP	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

THROTTLE POSITION AT LEVEL	COUNT	PERCENT	GEAR SHIFT POSITION AT GEAR	COUNT	PERCENT
CLOSED	[illegible]	[illegible]	1	0	[illegible]
WOT	[illegible]	[illegible]	2	0	[illegible]
			3	0	[illegible]
			4	0	[illegible]
			5	0	[illegible]
			6	0	[illegible]
			7	0	[illegible]

PERCENT OF TIME MV AT LEVEL	COUNT	PERCENT
0. - 1.	[illegible]	[illegible]
1. - 2.	[illegible]	[illegible]
2. - 3.	[illegible]	[illegible]
3. - 4.	[illegible]	[illegible]
4. - 5.	[illegible]	[illegible]
5. - 6.	[illegible]	[illegible]
6. - 7.	[illegible]	[illegible]
7. - 8.	[illegible]	[illegible]
8. - 9.	[illegible]	[illegible]
9. -10.	[illegible]	[illegible]
10. -11.	[illegible]	[illegible]
11. -12.	[illegible]	[illegible]
12. -13.	[illegible]	[illegible]
13. -14.	[illegible]	[illegible]
14. -15.	[illegible]	[illegible]
15. -16.	[illegible]	[illegible]
16. -17.	[illegible]	[illegible]
17. -18.	[illegible]	[illegible]
18. -19.	[illegible]	[illegible]
19. -20.	[illegible]	[illegible]
20. -21.	[illegible]	[illegible]
21. -22.	[illegible]	[illegible]
22. -23.	[illegible]	[illegible]
23. -24.	[illegible]	[illegible]
24. -25.	[illegible]	[illegible]
25. -26.	[illegible]	[illegible]
26. -27.	[illegible]	[illegible]
27. -28.	[illegible]	[illegible]
28. -29.	[illegible]	[illegible]
29. -30.	[illegible]	[illegible]

PERCENT OF TIME MS AT LEVEL	COUNT	PERCENT
0. - 2.	[illegible]	[illegible]
2. - 4.	[illegible]	[illegible]
4. - 6.	[illegible]	[illegible]
6. - 8.	[illegible]	[illegible]
8. -10.	[illegible]	[illegible]
10. -12.	[illegible]	[illegible]
12. -14.	[illegible]	[illegible]
14. -16.	[illegible]	[illegible]
16. -18.	[illegible]	[illegible]
18. -20.	[illegible]	[illegible]
20. -22.	[illegible]	[illegible]
22. -24.	[illegible]	[illegible]
24. -26.	[illegible]	[illegible]
26. -28.	[illegible]	[illegible]
28. -30.	[illegible]	[illegible]
30. -32.	[illegible]	[illegible]
32. -34.	[illegible]	[illegible]
34. -36.	[illegible]	[illegible]
36. -38.	[illegible]	[illegible]
38. -40.	[illegible]	[illegible]
40. -42.	[illegible]	[illegible]
42. -44.	[illegible]	[illegible]
44. -46.	[illegible]	[illegible]
46. -48.	[illegible]	[illegible]
48. -50.	[illegible]	[illegible]
50. -52.	[illegible]	[illegible]
52. -54.	[illegible]	[illegible]
54. -56.	[illegible]	[illegible]
56. -58.	[illegible]	[illegible]
58. -60.	[illegible]	[illegible]

PERCENT OF TIME RPM AT LEVEL	COUNT	PERCENT
0. - 200.	[illegible]	[illegible]
200. - 400.	[illegible]	[illegible]
400. - 600.	[illegible]	[illegible]
600. - 800.	[illegible]	[illegible]
800. -1000.	[illegible]	[illegible]
1000. -1200.	[illegible]	[illegible]
1200. -1400.	[illegible]	[illegible]
1400. -1600.	[illegible]	[illegible]
1600. -1800.	[illegible]	[illegible]
1800. -2000.	[illegible]	[illegible]
2000. -2200.	[illegible]	[illegible]
2200. -2400.	[illegible]	[illegible]
2400. -2600.	[illegible]	[illegible]
2600. -2800.	[illegible]	[illegible]
2800. -3000.	[illegible]	[illegible]
3000. -3200.	[illegible]	[illegible]
3200. -3400.	[illegible]	[illegible]
3400. -3600.	[illegible]	[illegible]
3600. -3800.	[illegible]	[illegible]
3800. -4000.	[illegible]	[illegible]
4000. -4200.	[illegible]	[illegible]
4200. -4400.	[illegible]	[illegible]
4400. -4600.	[illegible]	[illegible]
4600. -4800.	[illegible]	[illegible]
4800. -5000.	[illegible]	[illegible]

1970 FORD [illegible] RUN 2
RUN DURATION [illegible]

VAR	NO	MEAN	STD. DEV.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	RANGE
RPM	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MPH	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SPD	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TP	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PERCENT OF TIME THROTTLE POSITION AT

LEVEL	COUNT	PERCENT
CLOSED	2552	26.42
WOT	301	2.91

PERCENT OF TIME GEAR SHIFT POSITION AT

GEAR	COUNT	PERCENT
1	0	0.00
2	0	0.00
3	0	0.00
4	0	0.00
5	0	0.00
6	0	0.00
7	0	0.00

PERCENT OF TIME MPH AT

LEVEL	COUNT	PERCENT
0. - 200.	0	0.00
200. - 400.	0	0.00
400. - 600.	771	4.17
600. - 800.	2436	13.18
800. -1000.	683	5.47
1000. -1200.	795	5.76
1200. -1400.	1244	8.35
1400. -1600.	1787	23.82
1600. -1800.	1109	4.87
1800. -2000.	1122	8.48
2000. -2200.	1274	22.20
2200. -2400.	368	2.78
2400. -2600.	313	2.48
2600. -2800.	284	1.74
2800. -3000.	251	1.54
3000. -3200.	993	7.85
3200. -3400.	43	.34
3400. -3600.	85	.68
3600. -3800.	66	.53
3800. -4000.	11	.09
4000. -4200.	17	.14
4200. -4400.	12	.10
4400. -4600.	11	.09
4600. -4800.	0	0.00
4800. -5000.	0	0.00

PERCENT OF TIME MPH AT

LEVEL	COUNT	PERCENT
0. - 1.	484	7.07
1. - 2.	207	1.94
2. - 3.	260	2.24
3. - 4.	402	3.89
4. - 5.	375	3.55
5. - 6.	546	4.73
6. - 7.	334	2.67
7. - 8.	243	2.24
8. - 9.	249	2.14
9. -10.	524	4.14
10. -11.	401	2.91
11. -12.	465	3.24
12. -13.	341	2.77
13. -14.	1201	9.64
14. -15.	1140	9.47
15. -16.	944	7.57
16. -17.	413	3.31
17. -18.	324	2.41
18. -19.	425	3.41
19. -20.	537	4.91
20. -21.	471	4.24
21. -22.	494	3.95
22. -23.	191	1.52
23. -24.	164	1.32
24. -25.	21	.17
25. -26.	1	1.01
26. -27.	1	1.01
27. -28.	1	1.01
28. -29.	1	1.01
29. -30.	1	1.01

PERCENT OF TIME MPH AT

LEVEL	COUNT	PERCENT
0. - 2.	1754	14.84
2. - 4.	152	1.22
4. - 6.	142	1.14
6. - 8.	247	1.98
8. -10.	417	3.34
10. -12.	944	8.73
12. -14.	544	4.34
14. -16.	891	7.13
16. -18.	814	6.53
18. -20.	791	6.33
20. -22.	1011	8.11
22. -24.	764	6.11
24. -26.	440	3.48
26. -28.	576	4.77
28. -30.	652	6.42
30. -32.	483	3.87
32. -34.	213	1.70
34. -36.	196	1.57
36. -38.	256	2.15
38. -40.	82	.66
40. -42.	42	.48
42. -44.	65	.52
44. -46.	247	1.98
46. -48.	662	5.30
48. -50.	342	2.90
50. -52.	2	.02
52. -54.	1	1.01
54. -56.	1	1.01
56. -58.	1	1.01
58. -60.	0	0.00

PERCENT OF TIME MPH AT

LEVEL	COUNT	PERCENT
0. - 1.	484	7.07
1. - 2.	207	1.94
2. - 3.	260	2.24
3. - 4.	402	3.89
4. - 5.	375	3.55
5. - 6.	546	4.73
6. - 7.	334	2.67
7. - 8.	243	2.24
8. - 9.	249	2.14
9. -10.	524	4.14
10. -11.	401	2.91
11. -12.	465	3.24
12. -13.	341	2.77
13. -14.	1201	9.64
14. -15.	1140	9.47
15. -16.	944	7.57
16. -17.	413	3.31
17. -18.	324	2.41
18. -19.	425	3.41
19. -20.	537	4.91
20. -21.	471	4.24
21. -22.	494	3.95
22. -23.	191	1.52
23. -24.	164	1.32
24. -25.	21	.17
25. -26.	1	1.01
26. -27.	1	1.01
27. -28.	1	1.01
28. -29.	1	1.01
29. -30.	1	1.01

ENGINE AND VEHICLE PERFORMANCE
S.A.R.B. TRUCK 5

1970 CHEVROLET 18,000-LB GVW VAN
WITH 350 CID V-8 ENGINE

DATA FOR TRUCK 5
BEING PROCESSED

ENGINE AND VEHICLE PERFORMANCE
S.A.R.B. TRUCK 6

1974 FORD 24,000-LB GVW VAN
WITH 330 CID V-8 ENGINE

ENGINE AND VEHICLE PERFORMANCE
S.A.R.R. TRUCK 7

1970 GMC 19,500-LB GVW STAKE
WITH 351 CID V-8 ENGINE

DATA FOR TRUCK 7
BEING PROCESSED

ENGINE AND VEHICLE PERFORMANCE
S.A.E.R. TRUCK 8

1974 FORD 27,500 LB. GVW VAN
WITH 391 CID V-8 ENGINE

ENGINE AND VEHICLE PERFORMANCE
S.A.B.R. TRUCK 9

1972 FORD 24,000 LB. GVW VAN
WITH 330 CID V-8 ENGINE

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	PERCENT OF TIME THROTTLE POSITION AT		[illegible]	PERCENT OF TIME GEAR SHIFT POSITION AT	
	LEVEL	COUNT	PERCENT	GEAR	COUNT	PERCENT
[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	6	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]

PERCENT OF TIME [illegible] AT			PERCENT OF TIME [illegible] AT			PERCENT OF TIME [illegible] AT		
LEVEL	COUNT	PERCENT	LEVEL	COUNT	PERCENT	LEVEL	COUNT	PERCENT
<			<			<		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1972 FORD [illegible] LN CUA VAN 350 CID 4V THICK 4 BBL/BARREL RUN +
RUN DURATION 22.12 MIN TRUE SPEED 500 AMP TRUE VAC 18.1 INCHES HG

VAR NT	MEAN	S.D.	S.E. OF MEAN	SAMPLE	MAXIMUM	MINIMUM	VALUE
RPM 1	1470.71RM	555.4487	5.7535	4348	3500.0000	337.0000	3247.7700
MAP 2	11.2392	7.4400	.1134	4348	21.4400	.2760	21.2760
SPD 3	18.8206	17.8450	.2722	4348	44.4333	1.7000	44.4333
TP 4	4.7649	1.3147	.0199	4348	7.3000	4.2500	4.7500

PERCENT OF TIME TRANSMISSION AT LEVEL

COUNT	PERCENT
0	0.00

PERCENT OF TIME GEAR SHIFT POSITION AT

GEAR	COUNT	PERCENT
1	2	.05
2	517	22.82
3	334	14.74
4	548	24.19
5	851	37.56
6	3	.13
7	7	0.00

PERCENT OF TIME MPH AT

LEVEL	COUNT	PERCENT
0. - 2.5,	1	0.00
2.5, - 5.0,	7	.05
5.0, - 7.5,	181	1.43
7.5, - 10.0,	1240	13.04
10.0, - 12.5,	960	4.59
12.5, - 15.0,	1357	12.43
15.0, - 17.5,	1784	11.59
17.5, - 20.0,	1762	14.42
20.0, - 22.5,	1172	11.84
22.5, - 25.0,	1237	11.29
25.0, - 27.5,	474	4.45
27.5, - 30.0,	474	5.15
30.0, - 32.5,	454	5.05
32.5, - 35.0,	198	1.27
35.0, - 37.5,	47	.73
37.5, - 40.0,	24	.17
40.0, - 42.5,	11	.17
42.5, - 45.0,	4	.06
45.0, - 47.5,	1	0.00
47.5, - 50.0,	1	0.00
50.0, - 52.5,	1	0.00
52.5, - 55.0,	1	0.00
55.0, - 57.5,	1	0.00
57.5, - 60.0,	1	0.00

PERCENT OF TIME TP AT

LEVEL	COUNT	PERCENT
0. - 1.	738	7.91
1. - 2.	1884	17.57
2. - 3.	490	5.96
3. - 4.	430	4.42
4. - 5.	264	2.84
5. - 6.	230	2.47
6. - 7.	209	2.24
7. - 8.	227	2.44
8. - 9.	144	1.55
9. - 10.	135	1.45
10. - 11.	202	2.17
11. - 12.	193	2.07
12. - 13.	179	1.91
13. - 14.	157	1.68
14. - 15.	221	2.34
15. - 16.	436	4.68
16. - 17.	1154	11.42
17. - 18.	319	3.42
18. - 19.	154	1.65
19. - 20.	921	9.84
20. - 21.	961	27.42
21. - 22.	117	1.24
22. - 23.	0	0.00
23. - 24.	0	0.00
24. - 25.	0	0.00
25. - 26.	0	0.00
26. - 27.	0	0.00
27. - 28.	0	0.00
28. - 29.	0	0.00
29. - 30.	0	0.00

PERCENT OF TIME MS AT

LEVEL	COUNT	PERCENT
0. - 2.	1720	17.94
2. - 4.	262	2.81
4. - 6.	233	2.57
6. - 8.	196	2.20
8. - 10.	241	2.87
10. - 12.	424	4.34
12. - 14.	521	5.47
14. - 16.	543	5.83
16. - 18.	617	6.47
18. - 20.	556	5.87
20. - 22.	696	7.40
22. - 24.	666	7.26
24. - 26.	724	7.38
26. - 28.	587	6.31
28. - 30.	441	4.79
30. - 32.	499	5.36
32. - 34.	244	2.67
34. - 36.	123	1.37
36. - 38.	115	1.24
38. - 40.	162	1.74
40. - 42.	174	1.17
42. - 44.	139	1.47
44. - 46.	21	.21
46. - 48.	0	0.00
48. - 50.	0	0.00
50. - 52.	0	0.00
52. - 54.	0	0.00
54. - 56.	0	0.00
56. - 58.	0	0.00
58. - 60.	0	0.00

ENGINE AND VEHICLE PERFORMANCE
S.A.E. J.R. TRUCK 10

1972 FORD 1/2 200 LB. GVW VAN
WITH 351 CID V-8 ENGINE

ENGINE AND VEHICLE PERFORMANCE
S, A, R, R, TRUCK II

1970 DODGE 24,000 LB, GVW VAN
WITH 318 CID V-8 ENGINE

[illegible] [illegible] [illegible] [

ENGINE AND VEHICLE PERFORMANCE
by A, B, R, R, TRUCK 14

1973 IHC 22,500 LB. GVW VAN
WITH 345 CID V-8 ENGINE

ENGINE AND VEHICLE PERFORMANCE
S,A,R,R, TRUCK 13

1974 IHC 17,000-LB GVW VAN
WITH 304 CID V-8 ENGINE

[illegible]

[illegible]

[illegible]

[illegible]

ENGINE AND VEHICLE PERFORMANCE
S, A, R, R, TRUCK 14

1978 IHC 24,500 LB, GVW VAN
WITH 345 CID V-8 ENGINE

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PERCENT OF TIME THROTTLE POSITION AT

LEVEL	COUNT	PERCENT
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

PERCENT OF TIME [illegible] SHIFT POSITION AT

[illegible]	COUNT	PERCENT
1	[illegible]	[illegible]
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	[illegible]	[illegible]
6	[illegible]	[illegible]
7	[illegible]	[illegible]

PERCENT OF TIME [illegible] AT

LEVEL	COUNT	PERCENT
[illegible]	[illegible]	[illegible]
0. - 1.	2264	21.70
1. - 2.	1895	18.52
2. - 3.	336	3.22
3. - 4.	164	1.79
4. - 5.	161	1.54
5. - 6.	139	1.33
6. - 7.	159	1.52
7. - 8.	97	.93
8. - 9.	145	1.39
9. - 10.	103	.99
10. - 11.	88	.84
11. - 12.	111	1.06
12. - 13.	95	.91
13. - 14.	48	.46
14. - 15.	119	1.14
15. - 16.	186	1.78
16. - 17.	205	1.97
17. - 18.	281	2.69
18. - 19.	1348	12.92
19. - 20.	907	8.69
20. - 21.	219	2.10
21. - 22.	268	2.57
22. - 23.	606	5.81
23. - 24.	1797	17.22
24. - 25.	126	1.21
25. - 26.	0	0.00
26. - 27.	0	0.00
27. - 28.	0	0.00
28. - 29.	0	0.00
29. - 30.	0	0.00

PERCENT OF TIME [illegible] AT

LEVEL	COUNT	PERCENT
[illegible]	[illegible]	[illegible]
0. - 2.	1748	17.76
2. - 4.	263	2.62
4. - 6.	235	2.25
6. - 8.	234	2.24
8. - 10.	241	2.31
10. - 12.	570	5.46
12. - 14.	503	4.82
14. - 16.	365	3.49
16. - 18.	431	4.13
18. - 20.	465	4.46
20. - 22.	521	4.99
22. - 24.	484	4.63
24. - 26.	439	4.21
26. - 28.	552	5.29
28. - 30.	494	4.67
30. - 32.	444	4.26
32. - 34.	501	4.80
34. - 36.	159	1.48
36. - 38.	146	1.40
38. - 40.	165	1.77
40. - 42.	117	1.12
42. - 44.	76	.72
44. - 46.	71	.68
46. - 48.	225	2.16
48. - 50.	84	.81
50. - 52.	44	.42
52. - 54.	30	.29
54. - 56.	19	.18
56. - 58.	0	0.00
58. - 60.	0	0.00

PERCENT OF TIME [illegible] AT

LEVEL	COUNT	PERCENT
[illegible]	[illegible]	[illegible]
0. - 200.	0	0.00
200. - 400.	18	.18
400. - 600.	62	.59
600. - 800.	488	4.68
800. - 1000.	1592	15.26
1000. - 1200.	803	7.70
1200. - 1400.	565	5.42
1400. - 1600.	469	4.50
1600. - 1800.	1138	10.91
1800. - 2000.	2479	23.77
2000. - 2200.	1042	9.99
2200. - 2400.	742	7.12
2400. - 2600.	393	3.77
2600. - 2800.	189	1.81
2800. - 3000.	430	4.12
3000. - 3200.	859	8.23
3200. - 3400.	19	.18
3400. - 3600.	0	0.00
3600. - 3800.	0	0.00
3800. - 4000.	0	0.00
4000. - 4200.	0	0.00
4200. - 4400.	0	0.00
4400. - 4600.	0	0.00
4600. - 5000.	0	0.00

APPENDIX D

RESULTS FOR LABORATORY GROUP (SURVEILLANCE) OF 145 VEHICLES USING CVS AND CONTINUOUS NDIR ON CHASSIS VERSION OF NINE-MODE FTP (FOURTH ROUND INSPECTION)

TABLE D-1. VEHICLE DESCRIPTION AND FOURTH ROUND EMISSION RESULTS - "TWELVE MONTHS" HEAVY DUTY GASOLINE SURVEILLANCE (as of June 1, 1972)

TABLE D-1. VEHICLE DESCRIPTION AND FOURTH ROUND EMISSION RESULTS--"TWELVE MONTHS" HEAVY DUTY GASOLINE SURVEILLANCE (Cont'd.) (as of July 1, 1972)

Code No.	Date Received	Truck No.	Manufacturer	Vehicle Model	Name	Engine CID	Cyl.	Carburetion (quantity)	GVW No.	Transmission Type	Test Miles	Exhaust Hydrocarbons (HC) as Propane "Bag 2"	Carbon Monoxide (CO) "Bag 2"	Oxides of Nitrogen (NOx) "Bag 2"	Carbon Monoxide (CO) "Bag 3"	Fuel Economy Test No.
1	1-11-72	01	Ford	1970	350	350	8-cyl	1	21,000	Automatic	23,445	520	1.42	3900	1796	71
2	1-18-72	02	Ford	1970	GMC	351	8	1	21,000	Automatic	23,996	356	0.73	3600	2047	72
3	1-11-72	03	Ford	1970	Dodge	318	8-cyl	1	21,000	Automatic	23,796	287	0.65	3500	1748	73
4	1-18-72	04	Ford	1970	Ford	360	8	1	21,000	Automatic	24,007	291	0.26	4000	1917	74
5	1-18-72	05	GMC	1970	GMC	366	8-cyl	4	21,700	Automatic	23,005	251	1.34	3700	1884	75
6	1-11-72	06	GMC	1970	GMC	366	8-cyl	4	21,700	Automatic	23,196	251	0.83	3700	2027	76
7	1-17-72	07	GMC	1970	GMC	366	8-cyl	4	21,700	Automatic	23,005	240	1.46	3400	1774	77
8	1-18-72	08	GMC	1970	GMC	366	8-cyl	4	21,700	Automatic	23,006	254	1.29	3400	1982	78
9	1-18-72	09	GMC	1970	GMC	366	8-cyl	4	21,700	Automatic	23,007	240	1.19	3237	2081	79
10	1-17-72	10	GMC	1970	Chev.	427	8-cyl	4	21,000	Automatic	23,000	240	0.84	3400	1972	80
11	1-17-72	11	GMC	1970	Chev.	427	8-cyl	4	21,000	Automatic	23,000	240	0.84	3400	1985	81
12	1-18-72	12	GMC	1970	Chev.	366	8-cyl	1	21,000	Diesel	23,221	240	0.77	700	1776	82
13	1-18-72	13	GMC	1970	Chev.	366	8-cyl	1	21,000	Diesel	23,000	240	0.81	600	1784	83
14	1-11-72	14	Studebaker	1970	Dodge	318	8-cyl	4	20,000	Straight	23,227	251	1.34	3400	1976	84
15	1-18-72	15	Studebaker	1970	Dodge	318	8-cyl	4	20,000	Straight	23,000	251	1.16	3400	1972	85
16	1-18-72	16	GMC	1970	Dodge	318	8-cyl	1	21,000	Manual	23,000	240	1.17	3400	1984	86
17	1-18-72	17	GMC	1970	Dodge	318	8-cyl	1	21,000	Automatic	23,221	251	1.16	3400	1985	87
18	1-18-72	18	GMC	1970	Ford	361	8-cyl	1	21,000	Diesel	23,000	251	1.14	700	1911	88
19	1-11-72	19	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	89
20	1-11-72	20	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	90
21	1-11-72	21	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	91
22	1-11-72	22	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	92
23	1-11-72	23	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	93
24	1-11-72	24	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	94
25	1-11-72	25	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	95
26	1-11-72	26	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	96
27	1-11-72	27	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	97
28	1-11-72	28	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	98
29	1-11-72	29	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	99
30	1-11-72	30	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	100
31	1-11-72	31	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	101
32	1-11-72	32	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	102
33	1-11-72	33	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	103
34	1-11-72	34	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	104
35	1-11-72	35	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	105
36	1-11-72	36	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	106
37	1-11-72	37	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	107
38	1-11-72	38	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	108
39	1-11-72	39	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	109
40	1-11-72	40	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	110
41	1-11-72	41	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	111
42	1-11-72	42	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	112
43	1-11-72	43	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	113
44	1-11-72	44	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	114
45	1-11-72	45	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	115
46	1-11-72	46	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	116
47	1-11-72	47	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	117
48	1-11-72	48	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	118
49	1-11-72	49	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	119
50	1-11-72	50	GMC	1970	GMC	366	8-cyl	1	21,000	Gasoline	23,000	251	1.34	3700	1944	120

* Not in use. Replaced with engine of lower displacement.

TABLE D-1 VEHICLE DESCRIPTION AND FOURTH BOUND EMISSION RESULTS--"TWELVE MONTHS" HEAVY DUTY GASOLINE SURVEILLANCE (Cont'd.) (as of July 1, 1972)

TABLE D-2. ROUND 4 AVERAGE EMISSION INSPECTION RESULTS
BY ENGINE MODEL - HYDROCARBONS (PPM HEX.)

Manufacturer	CID	Cyl	Number In Group	Mean	Min	Max	Standard Deviation
Chevrolet (5)*	366	V8	4	152	121	184	64.5
Ford (10)	300	6	14	192	120	272	40.3
GMC (17)	350	V8	4	196	184	214	21.4
Chevrolet (4)	350	V8	7	200	124	290	64.5
GMC (16)	292	6	5	200	125	291	65.3
White (23)	400	6	5	202	129	311	74.2
Chevrolet (2)	292	6	2	202	179	225	32.5
Chevrolet (3)	307	V8	10	207	164	259	10.7
Chevrolet (6)	427	V8	2	232	231	232	0.7
Ford (11)	302	V8	1	235	-	-	-
Dodge (7)	225	6	8	238	175	300	43.5
IHC (19)	304	V8	13	242	166	324	34.3
IHC (20)	345	V8	8	248	186	302	41.7
Ford (9)	240	6	2	250	211	288	54.4
Ford (13)	360	V8	5	251	237	272	13.3
Chevrolet (1)	250	6	4	251	223	272	20.3
IHC (21)	392	V8	21	266	177	483	66.0
Ford (15)	391	V8	4	281	224	340	64.7
Dodge (8)	318	V8	15	288	212	355	38.7
GMC (18)	401	V6	1	298	-	-	-
Ford (14)	361	V8	3	399	282	586	163.6
IHC (22)	478	V8	7	572	153	1922	614.0
Ford (12)	330	V8	4	811	253	2093	860.0

*Category designation. See Appendix A for specific units included.

TABLE D-3. ROUND 4 AVERAGE EMISSION INSPECTION RESULTS
BY ENGINE MODEL - CARBON MONOXIDE (PERCENT)

Manufacturer	CID	Cyl.	Number In Group	Mean	Min.	Max.	Standard Deviation
Ford (11)*	302	V8	1	.97	-	-	-
Ford (10)	300	6	14	1.01	.15	4.78	1.330
Chevrolet (2)	292	6	2	1.02	.84	1.19	.248
GMC (16)	292	6	5	1.14	.51	1.96	.637
Chevrolet (5)	366	V8	2	1.21	.75	1.66	.554
Chevrolet (1)	250	6	4	1.23	.68	1.8	.481
BHG (20)	345	V8	8	1.30	.91	1.62	.223
BHG (19)	304	V8	13	1.34	.86	2.24	.393
BHG (22)	478	V8	7	1.48	.80	1.97	.337
Chevrolet (4)	350	V8	7	1.56	.87	2.37	.554
Ford (12)	330	V8	4	1.71	.73	3.89	1.483
GMC (17)	350	V8	2	1.82	1.33	2.30	.686
Dodge (8)	318	V8	15	1.83	1.45	2.23	.245
Ford (9)	240	6	2	1.85	1.82	1.87	.035
Ford (14)	361	V8	3	1.87	1.55	2.48	.531
Ford (15)	391	V8	4	1.93	.74	3.36	1.290
Dodge (7)	225	6	8	1.96	1.44	2.17	.264
Ford (13)	360	V8	5	2.24	1.65	2.90	.522
Chevrolet (6)	427	V8	2	2.34	1.82	2.85	.728
BMC (21)	393	V8	21	2.38	1.65	3.96	.554
Chevrolet (3)	307	V8	10	2.55	1.94	3.24	.431
White (23)	400	6	5	2.64	1.44	3.35	.725
GMC (18)	304	V6	1	4.90	-	-	-

*Category designation; see Appendix A for specific units included.

TABLE D-4. ROUND 4 AVERAGE EMISSION INSPECTION RESULTS BY ENGINE MODEL - OBSERVED NITRIC OXIDE (PPM)

Manufacturer	GID	Cyl.	Number In Group	Mean	Min	Max	Standard Deviation
Chevrolet (5)*	366	V8	2	690	439	941	185
GMC (18)	401	V6	1	904	-	-	-
Chevrolet (6)	427	V8	2	1020	591	1448	606
Chevrolet (4)	350	V8	7	1118	844	1438	185
IHC (21)	392	V8	21	1397	717	2143	368
IHC (22)	478	V8	7	1404	1035	1755	260
GMC (17)	350	V8	2	1498	1437	1559	86
Ford (9)	240	6	2	1627	1088	2165	762
Dodge (8)	318	V8	15	1634	946	2408	396
Ford (13)	360	V8	5	1659	1537	1853	128
Chevrolet (3)	307	V8	10	1730	1071	2328	409
Ford (14)	351	V8	3	1816	1120	2364	635
White (23)	400	6	5	1850	1484	2363	355
Ford (15)	391	V8	4	1932	1438	2302	435
Ford (12)	330	V8	4	2047	1553	2780	529
Dodge (7)	225	6	8	2100	1454	2565	347
IHC (19)	304	V8	13	2377	1492	2950	505
IHC (20)	345	V8	8	2429	1829	2862	335
GMC (16)	292	6	5	2456	1064	3681	1298
Ford (11)	302	V8	1	2469	-	-	-
Ford (10)	300	6	14	2478	1256	4008	849
Chevrolet (1)	250	6	4	2608	2026	3134	528
Chevrolet (2)	292	6	2	2659	2635	2683	34

*Category designation, see Appendix A for specific units included.

TABLE D-5. ROUND 4 AVERAGE EMISSION INSPECTION RESULTS BY ENGINE MODEL - CORRECTED NITRIC OXIDE (PPM)

Manufacturer	CID	Cyl.	Number In Group	Mean	Min.	Max.	Standard Deviation
Chevrolet (5)*	366	V8	2	628	378	878	189
GMC (18)	401	V6	1	795	-	-	-
Chevrolet (6)	427	V8	2	981	591	1370	550
Chevrolet (4)	350	V8	7	1142	819	1415	189
IHC (22)	478	V8	7	1274	1011	1517	175
IHC (21)	392	V8	21	1300	720	1865	324
Ford (9)	240	6	2	1301	870	1732	610
Ford (13)	360	V8	5	1478	1371	1629	109
Dodge (8)	318	V8	15	1509	918	2012	311
GMC (17)	350	V8	2	1517	1421	1613	136
White(23)	400	6	5	1521	1140	1938	306
Chevrolet (3)	307	V8	10	1578	1071	1969	16
Ford (14)	361	V8	3	1599	1054	2090	520
Ford (15)	391	V8	4	1910	1511	2269	425
Ford (12)	330	V8	4	1944	1267	2727	607
IHC (20)	345	V8	8	2008	1648	2274	228
Dodge (7)	225	6	6	2034	1460	2447	344
IHC (19)	304	V8	13	2138	1482	2583	373
Chevrolet (1)	250	6	4	2145	1653	2698	214
Ford (11)	302	V8	1	2262	-	-	-
Ford (10)	300	6	14	2293	1150	3174	780
GMC (16)	292	6	5	2307	1001	3696	1164
Chevrolet (2)	292	6	2	2455	2385	2524	98

*Category designation; see Appendix A for specific units included.

TABLE D-6. CONSTANT VOLUME SAMPLER TEST RESULTS
9-MODE FEDERAL CYCLE
HEAVY DUTY GASOLINE SURVEILLANCE

Unit No.	Date Tested	Vehicle Year	Make	Engine CID	Cyl.	Grams/Test HC	CO	NO_x	Grams/lb of Fuel HC	CO	NO_x
1	1-25-72	1970	Dodge	318	V8	63	682	83	12.43	134	16.29
2	1-25-72	1970	Dodge	318	V8	61	760	85	11.74	145	16.24
3	1-26-72	1970	Dodge	318	V8	63	539	45	12.18	104	8.61
4	1-26-72	1970	Dodge	318	V8	69	648	54	13.46	125	10.48
5	1-27-72	1970	Dodge	318	V8	40	375	22	9.47	90	5.41
6	1-31-72	1970	White	400	6	81	618	120	12.39	95	18.43
7	2-2-72	1970	White	400	6	54	1322	68	7.26	179	9.14
8	1-28-72	1970	White	400	6	69	1017	82	10.03	148	11.93
9	1-31-72	1970	White	400	6	121	1141	101	17.14	161	14.34
10	2-2-72	1970	White	400	6	57	1316	105	7.59	176	14.04
11	1-18-72	1970	IHC	478	V8	106	840	82	14.15	112	10.92
12	1-20-72	1970	IHC	478	V8	78	447	90	10.19	58	11.76
13	2-17-72	1970	IHC	478	V8	102	496	109	14.72	71	15.70
14	2-14-72	1970	IHC	478	V8	108	865	80	13.87	110	10.15
15	2-29-72	1970	IHC	345	V8	77	514	84	14.28	95	15.60
16	2-3-72	1970	IHC	345	V8	73	515	120	12.15	85	19.86
17	2-3-72	1970	IHC	345	V8	59	420	109	10.05	71	18.46
18	2-4-72	1970	IHC	345	V8	71	482	145	11.41	78	23.34
19	2-8-72	1970	IHC	345	V8	63	533	107	10.23	87	17.44
20	2-14-72	1970	Ford	300	6	43	306	64	10.19	72	15.12
21	Transferred to another city										
22	2-7-72	1970	IHC	392	V8	63	874	66	8.67	121	9.18
23	2-8-72	1970	IHC	392	V8	72	715	89	10.59	105	13.02
24	5-2-72	1971	IHC	392	V8	84	636	45	13.27	110	7.18
25	2-15-72	1970	IHC	392	V8	70	400	43	10.31	59	6.24
26	2-15-72	1971	IHC	304	V8	52	263	119	9.42	48	21.82
27	2-11-72	1970	Ford	300	6	36	145	85	8.64	35	20.55
28	2-16-72	1970	Ford	300	6	34	175	51	8.97	45	13.00
29	2-10-72	1970	Ford	300	6	39	169	140	7.88	33	28.13
30	2-10-72	1970	Chev.	292	6	45	292	78	10.80	69	18.49

TABLE D-5(con't). CONSTANT VOLUME SAMPLER TEST RESULTS
9-MODE FEDERAL CYCLE
HEAVY DUTY GASOLINE SURVEILLANCE

Unit No.	Date Tested	Vehicle Year	Make	Engine CID	Cyl.	Grams/Test HC	CO	NO_x	Grams/lb of Fuel HC	CO	NO_x
31	2-9-72	1970	Chev.	250	6	49	344	63	12.40	87	15.99
32	2-9-72	1970	Chev.	250	6	40	227	80	10.92	62	21.83
33	Transferred to another city										
34	Transferred to another city										
35	Transferred to another city										
36	2-17-72	1970	Chev.	250	6	49	438	64	11.78	105	15.38
37	2-18-72	1970	Chev.	250	6	42	168	105	11.25	45	28.14
38	2-18-72	1970	IHC	304	V8	57	314	108	11.75	65	22.22
39	2-21-72	1970	Ford	300	6	50	664	61	9.78	109	9.91
40	2-21-72	1970	Ford	300	6	28	44	130	5.73	9	26.81
41	2-22-72	1970	Ford	300	6	33	148	75	6.96	31	15.74
42	2-16-72	1970	Ford	300	6	34	156	59	8.60	40	22.61
43	2-22-72	1970	Ford	300	6	38	125	134	7.82	26	27.61
44	2-24-72	1970	Ford	300	6	44	177	89	10.82	44	21.90
45	2-23-72	1970	Ford	300	6	32	127	79	6.89	27	17.00
46	2-23-72	1970	IHC	304	V8	62	529	66	11.90	101	12.65
47	3-05-72	1970	IHC	304	V8	46	298	133	8.80	57	25.42
48	2-26-72	1970	IHC	304	V8	53	449	104	9.66	81	18.73
49	4-15-72	1970	IHC	304	V8	53	375	101	7.79	80	21.64
50	3-11-72	1970	IHC	304	V8	54	691	76	9.96	138	14.11
51	2-30-72	1970	IHC	304	V8	63	537	71	10.71	92	12.11
52	3-30-72	1970	GMC	292	6	65	269	139	14.63	61	31.53
53	3-01-72	1970	Dodge	318	V8	55	436	62	12.05	98	13.30
54	3-30-72	1970	Ford	330	6	35	95	155	8.27	23	37.11
55	2-26-72	1970	IHC	304	V8	62	451	109	11.33	83	19.97
56	3-05-72	1970	IHC	304	V8	55	400	117	8.58	62	18.00
57	2-26-72	1970	IHC	304	V8	62	490	98	11.63	93	18.57
58	3-04-72	1970	IHC	304	V8	45	374	55	8.43	71	10.31
59	3-04-72	1970	IHC	304	V8	56	367	106	10.49	68	19.71
60	2-27-72	1970	Chev.	307	V8	38	1006	63	6.36	168	10.41

TABLE D-6(con't). CONSTANT VOLUME SAMPLER TEST RESULTS
9-MODE FEDERAL CYCLE
HEAVY DUTY GASOLINE SURVEILLANCE

Unit No.	Date Tested	Vehicle Year	Make	Engine CID	Cyl.	Grams/Test HC	CO	NO_x	Grams/lb of Fuel HC	CO	NO_x
61	3-27-72	1970	Chev.	307	V8	48	1057	67	7.88	174	11.05
62	4-15-72	1970	Chev.	307	V8	37	388	59	5.62	59	9.05
63	3-18-72	1970	Chev.	366	V8	38	787	25	5.08	105	3.34
64	3-01-72	1970	Dodge	318	V8	74	660	76	11.57	103	11.92
65	3-29-72	1970	Dodge	318	V8	101	786	99	18.66	146	18.38
66	3-18-72	1970	Dodge	318	V8	53	583	56	10.53	117	11.21
67	3-14-72	1970	Dodge	318	V8	49	464	76	9.91	95	15.52
68	3-29-72	1970	Ford	361	V8	64	591	98	10.45	97	16.08
69	3-01-72	1970	IHC	392	V8	70	719	47	11.72	121	7.91
70	3-01-72	1970	IHC	392	V8	59	616	56	9.94	104	9.50
71	3-02-72	1971	IHC	345	V8	97	637	106	16.39	107	17.79
72	3-02-72	1970	IHC	345	V8	36	253	95	6.34	47	17.61
73	3-23-72	1970	IHC	392	V8	94	476	37	13.83	70	5.43
74	3-08-72	1970	IHC	392	V8	95	399	69	14.23	60	10.32
75	4-29-72	1970	Dodge	225	6	34	465	38	6.12	83	6.68
76	4-29-72	1970	Dodge	225	6	38	422	28	9.55	106	7.07
77	4-29-72	1970	Dodge	225	6	37	307	43	11.40	94	13.05
78	4-8-72	1970	Ford	302	V8	58	292	81	11.72	59	16.24
79	4-8-72	1970	GMC	401	V6	77	1513	38	11.92	234	5.95
80	4-5-72	1970	Chev.	307	V8	57	698	44	11.22	138	8.60
81	3-22-72	1970	Ford	300	6	33	839	41	5.65	146	7.17
82	3-23-72	1970	Ford	300	6	46	153	96	11.68	39	24.30
83	3-22-72	1970	Ford	361	V8	83	619	90	13.63	102	14.78
84	3-21-72	1970	Ford	361	V8	139	844	113	21.94	133	17.77
85	Wrecked										
86	4-8-72	1970	Dodge	225	6	35	535	63	6.14	93	10.90
87	4-9-72	1970	Dodge	225	6	27	369	65	7.79	105	18.49
88	4-9-72	1970	Dodge	225	6	28	416	52	5.98	88	11.10
89	4-9-72	1970	Dodge	225	6	37	568	95	7.68	117	19.62
90	4-29-72	1970	Dodge	225	6	30	329	30	9.37	101	9.22

TABLE D-6(cont'd) CONSTANT VOLUME SAMPLER TEST RESULTS
9-MODE FEDERAL CYCLE
HEAVY DUTY GASOLINE SURVEILLANCE

Unit No.	Date Tested	Vehicle Year	Make	Engine CID	Cyl.	Grams/Test HC	CO	NO_x	Grams/lb of Fuel HC	CO	NO_x
91	3-15-72	1970	IHC	345	V8	53	342	67	14.62	89	13.94
92	3-28-72	1970	Ford	360	V8	61	584	77	11.61	111	14.59
93	3-29-72	1970	Ford	360	V8	54	383	97	10.82	77	11.57
94	3-25-72	1970	Chev.	292	6	37	272	102	7.64	56	21.05
95	3-25-72	1970	Ford	360	V8	74	813	59	12.94	142	10.35
96	3-31-72	1970	Ford	240	6	39	342	29	10.02	89	7.45
97	3-31-72	1970	Ford	240	6	46	470	55	11.27	114	13.90
98	4-4-72	1970	Ford	330	V8	59	287	105	10.82	53	19.30
99	4-5-72	1970	Ford	330	V8	283	290	102	54.43	56	20.04
100	4-5-72	1970	Ford	330	V8	77	715	78	13.56	126	13.75
101	3-31-72	1970	Ford	330	V8	89	1327	63	14.12	211	10.01
102	4-5-72	1970	Ford	360	V8	73	993	57	13.44	168	9.75
103	4-6-72	1970	Chev.	427	V8	28	1363	42	8.54	340	4.51
104	3-28-72	1970	Chev.	307	V8	40	378	85	7.26	68	15.38
105	4-09-72	1970	IHC	392	V8	60	665	84	10.56	99	14.78
106	4-09-72	1970	Ford	360	V8	62	670	87	10.11	111	14.35
107	3-25-72	1970	Chev.	307	V8	45	596	59	8.05	114	11.30
108	3-14-72	1970	Chev.	307	V8	51	450	65	8.47	74	10.71
109	3-14-72	1970	Chev.	307	V8	65	409	81	10.52	65	9.62
110	3-16-72	1970	Chev.	307	V8	47	741	76	9.38	147	15.11
111	3-16-72	1970	Chev.	307	V8	38	754	74	6.78	135	13.24
112	3-15-72	1970	Chev.	307	V8	63	427	66	8.90	72	11.13
113	4-4-72	1970	IHC	392	V8	98	929	44	9.13	147	6.94
114	4-6-72	1971	IHC	392	V8	69	575	41	8.83	93	6.67
115	4-12-72	1970	IHC	392	V8	94	1020	40	13.47	146	5.70
116	4-12-72	1970	GMC	350	V8	41	704	56	7.25	123	9.75
117	6-2-72	1970	Chev.	350	V8	29	307	33	5.40	57	6.21
118	4-11-72	1970	Dodge	318	V8	57	522	60	11.60	106	10.11
119	4-17-72	1970	Dodge	318	V8	75	636	43	13.14	137	9.10
120	4-18-72	1970	Dodge	318	V8	57	529	39	12.44	116	8.50

TABLE D-6. (Con't) CONSTANT VOLUME SAMPLER TEST RESULTS
9-MODE FEDERAL CYCLE
HEAVY DUTY GASOLINE SURVEILLANCE

Unit No.	Date Tested	Vehicle Year	Make	Engine CID	Cyl.	HC	CO	NO_x	HC	CO	NO_x
121	5-6-72	1970	GMC	292	6	47	121	145	6.99	35	31.73
122	5-7-72	1970	GMC	292	6	45	535	88	9.64	115	18.83
123	5-21-72	1970	GMC	292	6	47	477	39	9.94	104	8.44
124	5-7-72	1970	GMC	292	6	34	223	46	7.84	52	10.63
125	5-9-72	1970	Dodge	318	V8	74	637	47	14.92	129	7.57
126	5-12-72	1970	Dodge	318	V8	61	548	45	13.93	107	8.82
127	5-21-72	1971	Ford	391	V8	55	453	117	8.49	70	18.07
128	5-21-72	1971	Ford	391	V8	50	386	119	7.76	60	18.46
129	5-21-72	1971	Ford	391	V8	85	980	71	13.73	158	11.53
130			Converted to butane fuel								
131	4-26-72	1971	IHC	392	V8	60	654	38	8.46	93	5.40
132	4-24-72	1971	IHC	392	V8	77	898	46	10.85	126	6.41
133			Converted to butane fuel								
134	4-20-72	1971	IHC	392	V8	56	651	53	8.10	95	8.04
135	4-19-72	1971	IHC	392	V8	101	889	66	13.33	123	9.07
136	4-24-72	1971	IHC	392	V8	78	890	44	11.16	128	6.35
137	4-25-72	1971	IHC	392	V8	99	606	48	13.93	81	6.64
138	4-27-72	1971	IHC	392	V8	238	1405	38	31.19	184	4.54
139	4-26-72	1971	IHC	392	V8	80	669	43	11.65	97	6.19
140	4-20-72	1971	IHC	392	V8	74	843	90	10.94	124	7.38
141	5-21-72	1971	Ford	391	V8	78	1294	74	11.33	187	10.67
142	5-22-72	1971	IHC	478	V8	52	582	66	6.78	76	8.66
143	5-4-72	1971	IHC	478	V8	84	768	88	11.16	103	11.78
144	5-22-72	1971	IHC	478	V8	454	850	90	48.84	92	6.45
145	5-17-72	1971	Chev	350	V8	38	394	43	9.84	61	7.67
146	5-11-72	1971	Chev	350	V8	46	617	43	7.34	98	6.74
147	5-12-72	1971	Chev	350	V8	43	469	56	6.76	74	8.87
148	5-12-72	1971	Chev	350	V8	78	801	55	12.63	129	8.78
149	5-17-72	1971	Chev	350	V8	33	612	36	5.30	98	5.67
150	5-11-72	1971	Chev	350	V8	62	673	44	9.45	103	6.64
151	5-31-72	1971	Chev	427	V8	71	817	66	9.82	113	9.11
152	5-10-72	1971	Chev	350	V8	50	356	51	7.87	56	8.01

TABLE D-7. ROUND 4 AVERAGE CVS EMISSION RESULTS
BY ENGINE MODEL - HYDROCARBONS

Manufacturer	CID	Cyl	Number In Group	Average Grams/lb of fuel	Average Grams/test
Chevrolet	366	V8	2	5.35	38
GMC	350	V8	2	6.33	35
Chevrolet	350	V8	7	7.88	50
Dodge	225	6	8	8.00	33
Ford	300	6	14	8.42	38
Chevrolet	307	V8	10	8.52	48
GMC	292	6	5	9.01	40
Chevrolet	427	V8	2	9.18	75
Chevrolet	292	6	2	9.22	41
IHC	304	V8	13	10.03	54
Ford	391	V8	4	10.33	67
Ford	240	6	2	10.65	43
White	400	6	5	10.88	76
Chevrolet	250	6	4	11.59	45
Ford	360	V8	5	11.62	65
IHC	345	V8	8	11.72	67
IHC	392	V8	21	12.11	83
Dodge	318	V8	15	12.64	63
Ford	361	V8	3	15.34	95
IHC	478	V8	7	17.10	141
Ford	330	V8	4	23.23	127

TABLE D-8. ROUND 4 AVERAGE CVS EMISSION RESULTS
BY ENGINE MODEL - CARBON MONOXIDE

Manufacturer	CID	Cyl.	Number In Group	Average Grams/lb of fuel	Average Grams/test
Ford	300	6	14	49	237
Chevrolet	292	6	2	63	282
GMC	292	6	5	73	325
Chevrolet	250	6	4	75	294
IHC	304	V8	13	79	426
IHC	345	V8	8	80	462
Chevrolet	366	V8	2	82	588
Chevrolet	350	V8	7	88	560
IHC	478	V8	7	89	695
GMC	350	V8	2	90	506
Dodge	225	6	8	98	429
Ford	240	6	2	102	406
IHC	392	V8	21	109	738
Ford	361	V8	3	111	685
Ford	330	V8	4	112	655
Chevrolet	307	V8	10	116	650
Dodge	318	V8	15	117	587
Ford	391	V8	4	119	778
Ford	360	V8	5	122	689
Chevrolet	427	V8	2	131	1090
White	400	6	5	152	1083

TABLE D-9. ROUND 4 AVERAGE CVS EMISSION RESULTS
BY ENGINE MODEL - OBSERVED NITRIC OXIDE AS NO_2

Manufacturer	CID	Cyl.	Number In Group	Average Grams/lb of Fuel	Average Grams/test
Chevrolet	366	V8	4	6.20	41
Chevrolet	427	V8	4	6.84	54
Chevrolet	350	V8	7	7.48	48
IHC	392	V8	21	7.76	52
GMC	350	V8	4	7.98	45
IHC	478	V8	7	10.78	82
Dodge	318	V8	15	11.58	59
Chevrolet	307	V8	10	11.67	66
Ford	240	6	4	11.68	47
Dodge	225	6	8	12.03	52
Ford	360	V8	5	12.12	67
White	400	6	5	13.58	95
Ford	391	V8	4	14.68	95
Ford	330	V8	4	16.00	87
Ford	361	V8	3	16.21	100
IHC	345	V8	8	17.95	104
IHC	304	V8	13	18.11	97
Chevrolet	292	6	4	19.77	90
GMC	292	6	5	20.23	87
Chevrolet	250	6	4	20.33	78
Ford	300	6	14	20.50	92

TABLE D 10. EMISSION RESULTS FOR SURVEILLANCE FLEET VEHICLES REQUIRING TIMING OR IDLE SPEED ADJUSTMENTS FTP USING CONTINUOUS NDIR - TWELVE MONTH INSPECTION

TABLE D 11. EMISSION RESULTS FOR SURVEILLANCE FLEET VEHICLE REQUIRING TIMING OR IDLE SPEED ADJUSTMENTS FTP USING CONSTANT VOLUME SAMPLER - TWELVE MONTH INSPECTION

TABLE D-12. PERCENT CHANGE IN SURVEILLANCE FLEET CONTINUOUS NOX EMISSIONS FROM TIMING OR IDLE SPEED ADJUSTMENTS - TWELVE MONTH INSPECTION

ROUND NO. 4

TRUCK NUMBER	FORD/CUMMINS HP				CUMMINS ISM/ISX ECL				DETROIT DIESEL DDEC				CUMMINS ISL ECL			
	4S	2N	TORQ.	ACT.	4S	2N	TORQ.	ACT.	4S	2N	TORQ.	ACT.	4S	2N	TORQ.	ACT.
	RECEIVED	SPEC		DIFF.	RECEIVED	SPEC		DIFF.	RECEIVED	SPEC		DIFF.	RECEIVED	SPEC		DIFF.
7	252	217	+5	+2.7	1.51	1.42	.11	7.3	2527	2538	+481	+27.5	1446	1378	+277	+21.1
4	350	296	+59	+25.9	2.01	2.29	.28	5.6	2981	2939	+411	+27.8	1447	1389	+418	+27.3
17	179	173	+21	+22.8	1.12	1.12	7.77	7.3	4287	2228	14	.9	1446	1442	24	.28
37	215	261	+62	+34.2	2.63	2.58	+.05	+1.9	2951	937	+829	+35.9	1114	754	+367	+32.3
23	271	139	+62	+31.9	1.65	1.47	+.72	+1.9	1873	372	+1571	+47.1	1429	117	+1211	+74.3
47	242	211	+31	+12.8	.96	.88	+.76	+8.4	2852	2848	+232	+5.3	2527	2429	+98	+3.9
14	225	191	+34	+15.1	1.51	1.19	+.76	+8.9	3708	2447	+611	+7.8	2521	2157	+173	+7.8
58	196	216	92	30.1	1.15	1.79	+.76	+6.2	1492	3526	1934	+8.3	2482	2508	1226	+9.-
51	244	197	+47	+19.3	1.19	1.33	+.76	+6.1	2527	1403	+724	+48.4	2167	1442	+625	+29.4
46	229	161	168	151.4	1.68	1.92	+.76	+5.6	3441	2179	739	+5.0	2452	2438	786	44.4
9	212	226	17	6.4	1.47	1.89	+.79	+4.3	1741	2419	469	32.6	1219	2425	207	14.4
63	189	241	19	3.6	1.53	1.53	+.04	+1.5	1129	1256	138	18.3	1754	1184	130	12.7
64	186	382	+171	+34.9	2.48	2.54	.48	3.7	2364	2424	+441	+18.6	2240	1741	+489	+28.6
61	238	274	+36	+15.7	2.26	1.76	+.13	+6.4	2224	2224	0	0.0	2258	2258	0	0.7
6	211	311	139	47.4	1.82	1.89	.17	3.8	1188	2424	84	77.3	471	2343	872	77.4
18	2241	2484	+138	+4.4	.81	.82	.72	1.7	2782	2367	+1414	+42.4	2127	1224	+172	+42.8
233	231	224	+2	+.7	2.25	2.24	+.71	+.4	571	644	74	12.4	478	444	74	14.5
224	242	159	+84	+38.4	1.97	2.17	.13	4.4	1863	1388	+469	+25.3	2429	1217	+412	+25.7
231	208	132	+74	+34.5	.51	.74	+.15	+2.9	1441	2424	+1157	+31.4	1424	2133	+111	+31.5
232	224	148	+69	+11.4	1.76	1.68	.72	1.1	2744	2548	+445	+21.5	2741	2137	+604	+23.5
234	242	185	+55	+18.1	2.47	2.44	+.18	+4.7	2424	1474	248	14.4	2727	1984	286	24.7
235	278	185	73	27.8	2.24	2.71	.42	15.3	1741	2577	+824	+11.9	2845	2442	+223	+22.7
237	181	242	21	9.5	2.42	2.24	.41	15.3	1744	2284	+524	+28.4	2442	1287	+475	+25.4
251	248	244	17	7.3	1.58	1.47	+.15	+6.7	2448	2014	595	+1.1	2278	2433	562	41.1

AVERAGE PERCENT CHANGE HC +.2
CO +.2
NO +4.2
CYBN NO +4.2

TABLE D-11. PERCENT CHANGE IN SURVEILLANCE FLEET CVS EMISSION RESULTS FROM TIMING OR IDLE SPEED ADJUSTMENTS - TWELVE MONTH INSPECTION

Phase No. 1

Vehicle Number	HC AS RECEIVED	HC IN SPEC	HC DIFF.	HC PCT. DIFF.	CO AS RECEIVED	CO IN SPEC	CO DIFF.	CO PCT. DIFF.	NOx AS RECEIVED	NOx IN SPEC	NOx DIFF.	NOx PCT. DIFF.
2	41	43	-18	-29.5	761	662	-98	-12.9	85	58	-27	-31.8
4	44	44	-23	-34.3	448	470	-178	-27.5	54	24	-30	-55.6
17	58	59	-6	-10.2	427	418	-2	-.5	104	107	+2	+1.8
22	43	51	-5	-8.5	434	804	32	3.7	66	42	-24	-36.4
23	72	51	-21	-29.2	715	672	-43	-5.7	89	38	-51	-57.3
47	46	43	-7	-13.5	264	266	-4	-3.0	133	123	-17	-7.5
54	55	48	-7	-12.7	407	374	-24	-6.5	117	93	-24	-20.5
58	45	44	-1	-1.7	134	137	-17	-4.4	55	67	32	58.2
64	46	44	-12	-21.4	367	345	-22	-6.0	106	72	-34	-32.1
69	74	47	-34	-31.2	447	434	-26	-3.4	76	108	32	42.1
84	53	46	-8	-15.1	163	426	-57	-8.8	58	63	7	12.5
91	43	45	2	2.4	419	442	43	6.4	90	100	10	11.1
94	134	169	-36	-35.8	844	874	35	4.1	113	92	-21	-18.6
97	27	43	1	3.7	764	377	1	.3	65	58	-7	-10.8
98	44	48	4	23.1	342	361	19	5.6	29	48	19	65.5
99	243	249	-24	-44.4	247	285	-6	-1.7	109	96	-13	-11.9
103	78	74	+3	+3.8	1263	1325	-38	-2.8	42	34	-8	-19.0
104	42	47	-15	-24.2	470	492	22	3.3	47	59	-28	-32.2
121	27	26	-1	-3.7	121	118	-3	-2.5	125	88	-37	-29.6
124	43	47	-6	-11.1	435	537	2	.4	48	75	-13	-19.8
129	45	68	3	5.5	480	896	14	1.6	71	94	23	32.4
136	171	147	39	36.4	494	1117	221	24.4	65	67	+2	+3.0
137	99	118	14	15.2	404	709	96	15.5	48	42	-6	-12.5
141	71	74	3	4.2	417	747	-70	-8.6	46	107	+1	62.1

AVERAGE PERCENT CHANGE HC +1.1
CO -1.5
NO -4.5

TABLE D-14. MILEAGE ACCUMULATED DURING FIRST TWELVE MONTHS OF SURVEILLANCE TEST OF HDV (GASOLINE)

TABLE D-14 (CONT'D). MILEAGE ACCUMULATED DURING FIRST TWELVE MONTHS OF SURVEILLANCE TEST OF HDV (GASOLINE)

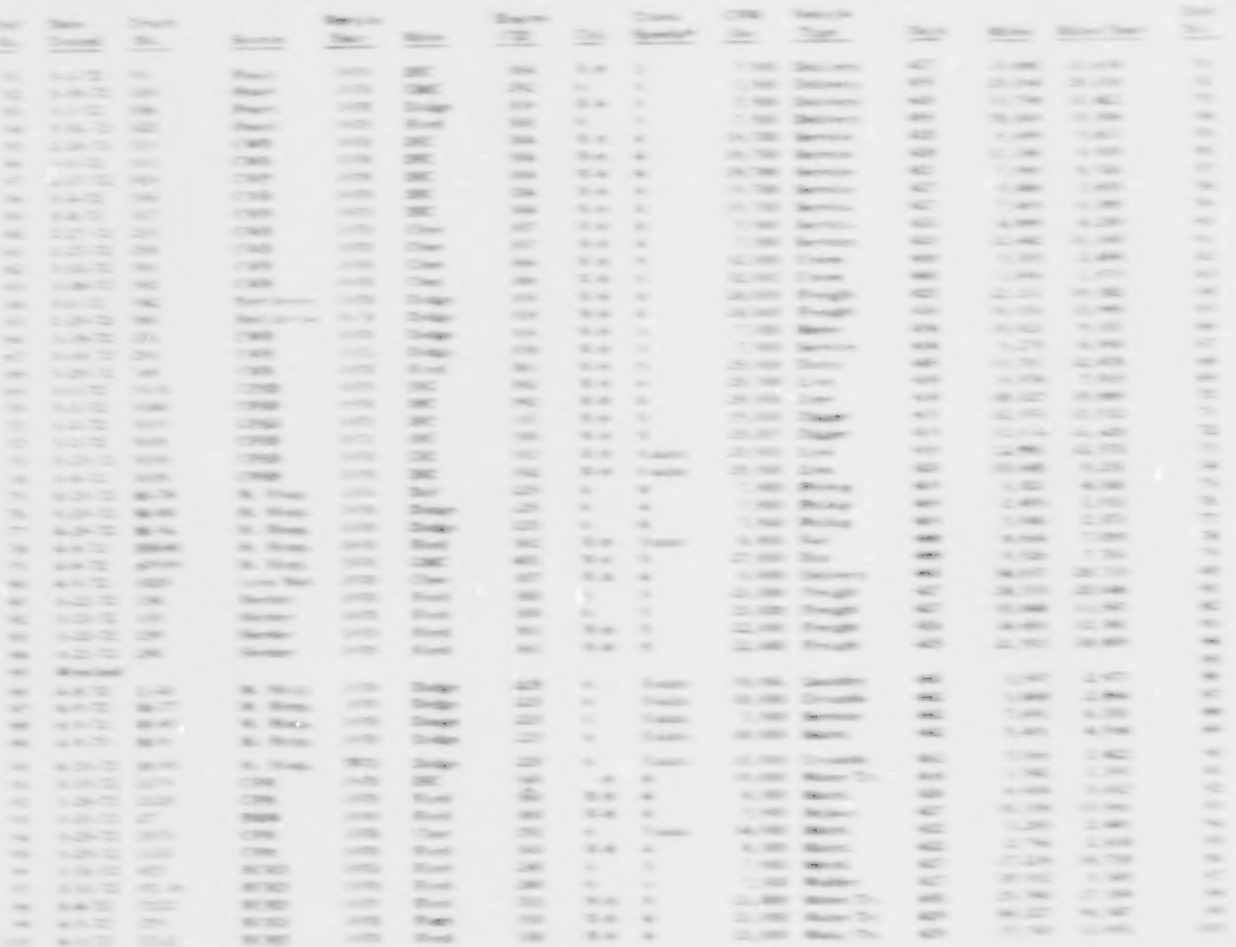

TABLE D 14-6(CON'T) MILEAGE ACCUMULATED DURING FIRST TWELVE MONTHS OF SURVEILLANCE TEST OF HDV (GASOLINE)

TABLE D-15. YEARLY MILEAGE FOR LABORATORY GROUP (SURVEILLANCE) VEHICLES BY MAKE AND DISPLACEMENT CLASSIFICATION

Model Group Identification Number	Description			Number In Group	Miles/Year		
	Make	CID	Cyl.		Average	Max.	Min.
1	Chevrolet	250	I-6	4	11,525	20,323	7,557
2	"	292	I-6	2	9,245	15,649	2,840
3	"	307	V-8	10	9,242	28,703	792
4	"	350	V-8	7	22,244	19,654	24,199
5	"	366	V-8	2	2,036	2,498	1,573
6	"	427	V-8	2	33,563	40,061	27,064
7	Dodge	225	I-6	8	3,446	6,351	1,911
8	"	318	V-8	15	9,373	19,302	5,625
9	Ford	240	I-6	2	12,032	14,718	9,345
10	"	300	I-6	14	12,045	20,646	3,353
11	"	302	V-8	1	7,059	-	-
12	"	330	V-8	4	25,718	56,347	17,308
13	"	360	V-8	5	8,197	15,494	2,418
14	"	361	V-8	3	14,689	18,809	12,381
15	"	391	V-8	4	11,486	12,943	7,813
16	GMC	292	I-6	5	16,084	20,130	9,863
17	"	350	V-8	2	4,863	5,840	3,885
18	"	401	V-6	1	7,761	-	-
19	IHC	304	V-8	13	10,442	21,089	3,835
20	"	345	V-8	8	15,433	26,162	1,359
21	"	392	V-8	21	9,759	20,653	1,845
22	"	478	V-8	7	22,384	34,993	15,429
23	White	400	I-6	5	16,688	16,996	16,041

a Based on First Twelve Months of Surveillance Test.